ILLUMINATING ENGINEERING

JANUARY 1953

In Two Sections — Section I

Techniques for Photography of Lighted Streets

Conference Papers from Daylighting Session

Dual Light Source Used in Machine Shop

Lighting an Airport Loading Apron

Lighting a Press Room

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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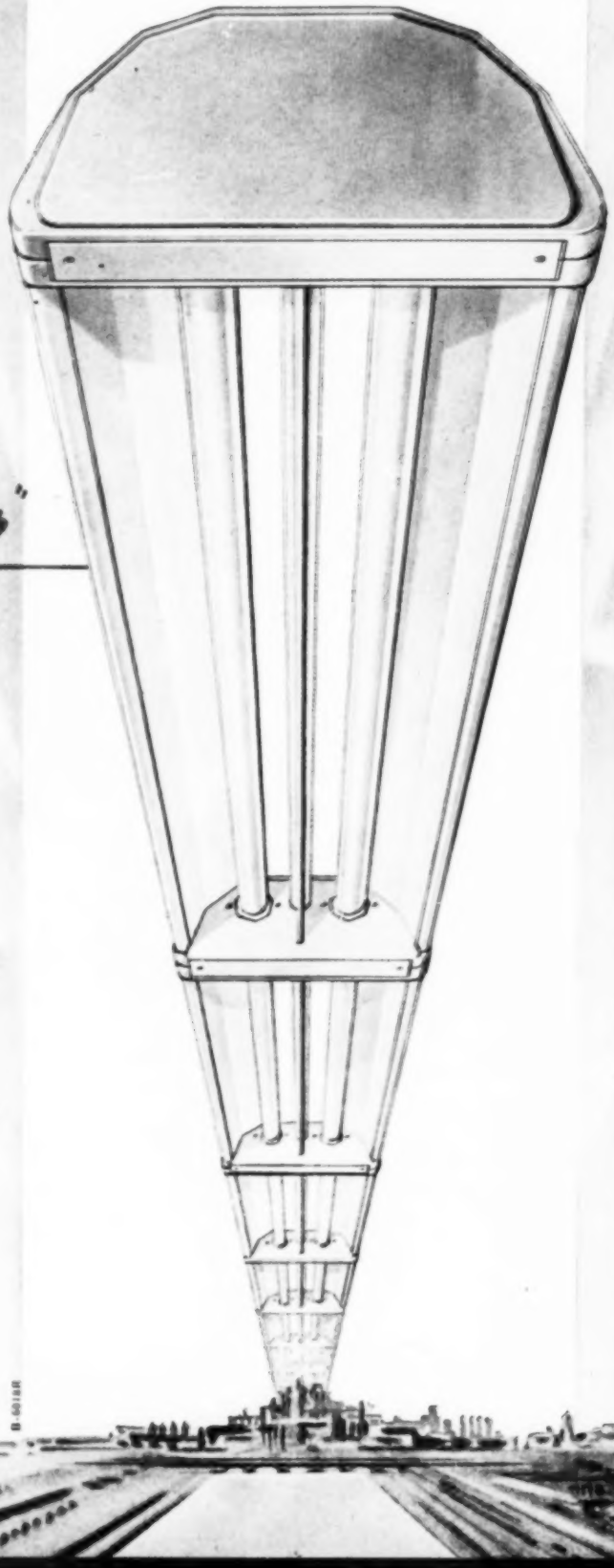

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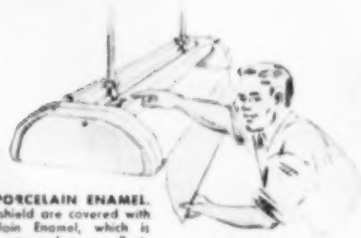

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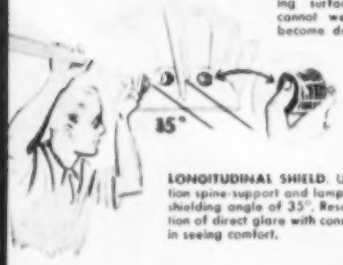

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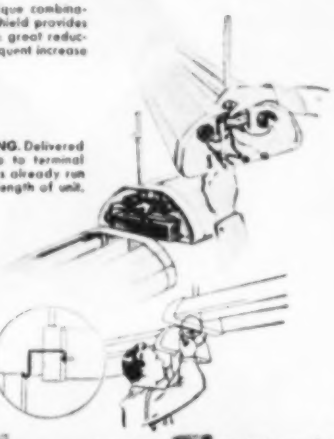

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LIGHTING DIVISION

Edgewater Park, Cleveland, Ohio

INSTALLATION: Boyle County Court House, Danville, Kentucky.
AREA: County Court Room — Hon. Judge Cheek, County Judge.
ARCHITECTS & ENGINEERS: Nevin & Morgan, Louisville, Kentucky.
ELECTRICAL CONTRACTOR: Simpson Electric Co., Danville, Kentucky.
CEILING HEIGHT: 16 Feet, Approximately.
CEILING: Flat White.
WALLS: Light Green.
FLOOR: Brown Cork.
FIXTURES: Litecontrol No. 5828 2-lamp recessed louvered troffers and No. 5838 3-lamp recessed louvered troffers, using T12/96 slimline lamps.
SPACING: 8'-6" on centers.
INTENSITY: Approximately 37 footcandles average in service.

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

JANUARY 1953

Vol. XLVIII

No. 1

In Two Sections

Section 1

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Founded 1906

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A. D. Hinckley
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SECOND I.E.S. INTER-REGION LIGHTING CONTEST FORMING UP

NEW YORK—Members of Illuminating Engineering Society sections and chapters all over the U. S. and in Canada are weighing every lighting job with extra care these days in preparation for this year's competition for the outstanding lighting job of the year 1953. Even at this early date interest is running high and many more entries are expected than in the first contest last year.

Three Contests in One

This competition is the official I.E.S. sponsored contest at the section, region and national levels to find the best in lighting jobs each year. At every level entries are judged by competent, qualified I.E.S. lighting experts whose rating sheets, covering every aspect of the job and its presentation, are the basis for cash awards.

Actually, any entry can participate in three separate contests—in the section or chapter; in the I.E.S. region; and finally in the national competition. In each contest cash prizes are awarded and presented at local meetings and at the regional conferences. The highest awards—first, second and third places nationally—are presented at the I.E.S. National Technical Conference being held this year in New York.

I.E.S. Practices and Standards Important

The present I.E.S. Inter Region Lighting Contest is only the second of these annual competitions of lighting jobs by lighting experts, sponsored and judged by other lighting experts. For this reason all entries should be based on the proper application of I.E.S. recommended and standard practices. Any type of lighting installation can be entered and can win one or more of the contests. There is no restriction, provided; first, the job conforms as closely as possible with I.E.S. standard practices. Lighting for a school, a church, a home, a baseball diamond, an industrial plant, a gas station, or even an outstanding supplementary lighting job can be entered.

More Entries Than Ever

Indications are that competition this year will be much keener than in 1952, if number of entries is any sign. More and more I.E.S. sections and chapters are sponsoring local contests to qualify for the competition in each region of the Society. Not only are members vying for the cash prizes, but nationally winning jobs gain nation-wide prominence through appearing in ILLUMINATING ENGINEERING.

Winning of one or more of the contests being held in connection with the current I.E.S. Inter Region Lighting Contests means real national and international recognition for outstanding lighting installations as well as substantial cash awards, which help to finance the winners' trips to I.E.S. regional conferences and the National Technical Conference.

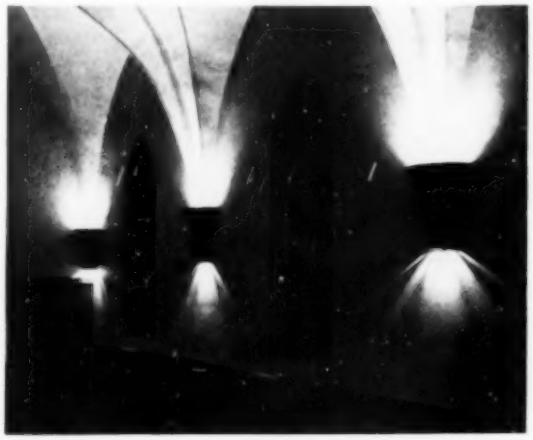
Entrance requirements may be obtained from section or chapter officers and entries should be filed as soon as possible.

Place your "most interesting lighting job" in national competition now!

GET YOUR JOB IN NOW!

1953 I.E.S. INTER • REGION LIGHTING CONTEST

"My Most Interesting Lighting Job"



FIRST I.E.S. Inter-Region Lighting Contest

1952 NATIONAL WINNER

Novel lighting effect which helped winning of top award for church lighting installation by Earl A. Domoney of the Michigan Section, at I.E.S. National Technical Conference, Chicago.

Rules for Entering Jobs

Members may obtain contest rules and enter their jobs through Section and Chapter officers. Practically every I.E.S. group is running a competition for 1953.

Remember!

Every I.E.S. Associate Member, Member, or Fellow* in good standing can enter his job and qualify for any or all of these cash awards. Enter your "most interesting lighting job" now!

**Except national officers and chairmen of national standing committees.*

Views and Opinions

Illuminating Engineers—
Orphans of the Industry

SELDOM within the history of American business have so many deserving and highly specialized men and women been denied the recognition that their profession and position warrants.

ILLUMINATING engineers, with their extensive training and the ambitious nature of their work, are contributing much to the American economy. They are the motivating force that is steering the people of our nation from their age-old complacency with poor lighting conditions to the acceptance of the present higher standards, and the outlook is for still brighter horizons.

BENEFITS already realized from these efforts are tremendous not only from the utilities' and electrical industries' viewpoint but for all of our citizens in terms of safety, improved health, better working conditions, and untold blessings to future mankind.

STILL there seems to be no interest or satisfactory provisions available in our state statutes to give us legal recognition of our jobs or titles. It is an accepted fact that a legitimately earned title designates authority and adds power and prestige to our words and enhances our value. With the present promiscuousness in the lighting business, it is possible for anyone to adopt the title of and operate as an "illuminating engineer" before he understands even the simplest fundamentals of lighting.

UTILITY companies, fixture manufacturers and associated electrical industries have for many years recognized the value to them of trained lighting employees and have made known their satisfaction with selective positions and pay brackets. In addition, they are spending sizeable sums in I.E.S. and other educational and promotional work.

WE are expected to completely understand the spectrums, and various light sources such as sodium, mercury, fluorescent, incandescent, neon, etc. Our specialization covers the field of street, sign, sportsfield, church, school, commercial and industrial lighting and a host of other applications. Our recommendations are important for they usually are the deciding factor. Our customers regard us as experts and we must be qualified to advise. There are also a multitude of lamps of different types and assortments; their uses are many and varied and constant diligence is necessary to properly recommend them.

UTILITY companies know that only well trained and highly specialized personnel are capable of maintaining the present lighting load and assume the responsibility of the normal increase expected each year.

PROOF of the good job done is shown in the following available statistics. The 80 billion kwh sold for lighting in 1948 was approximately 33 per cent of the 240 billion kwh sold for all purposes, in spite of the heavy added appliance load. However, utility experts predict 365 billion kwh in 1955. Therefore, if trained lighting people are available and lighting continues its usual growth, we should attain nationally in lighting a 50 per cent increase or 120 billion kwh.

MY OBJECT here is to point out to you the prominence of and the professional stature necessary for those who hope to make their lighting career a success. Also, that our requirements in education, salesmanship training and all-around experience equal those of any other group who by virtue of their professional status holds the only mythical legal title of illuminating engineer in the eyes of the public.

However, I am casting no reflection whatsoever on architects or graduate engineers, for with their professional background, comprehensive lighting interest and training, and their natural affinity to this field, they certainly are an asset to our industry. However, the great majority of us who are not registered engineers or architects but have given a lifetime of service to the lighting field feel that we have attained a degree of proficiency through an accepted educational schedule and practical lighting training which entitles us to be eligible for any legal degrees or titles that the lighting profession can hope to assume.

NOW how are we to attain this recognition and the advantages that it offers? In many states the legislatures have authorized the establishing of societies to embrace graduate engineers, lighting engineers, and practical engineers who through service have proven their abilities. Examining boards are set up to judge exhibits and to pass upon letters and other supporting evidence relating to the abilities of the applicant. Registered engineers and architects not associated with lighting generally head the boards. They are men of integrity, ability, and sincere in every way, but too often completely lack the knowledge of illuminating engineering problems as we lack knowledge of theirs. Consequently, written examinations which are generally always prescribed regardless of the applicants' practical qualifications are mostly foreign to illumination practices and design.

THE PRESENT setup is completely unacceptable to those of us who have adopted lighting as our life work and are interested in the improvement of it through training and broader recognition.

I AM presenting for your study three distinct plans. Without a doubt there are others, but we should be able to ascertain quite definitely from these the most logical and practical procedure to follow in getting the recognition we desire.

Plan No. 1

Join a union and request a proper and legal classification of lighting engineers in their bylaws. We might call this an escape rather than a plan although it should be recognized as a future possibility. In my opinion, however, the two are incompatible and should be eliminated without further discussion. Related plans established by most states to include barbers, electricians, plumbers, real estate agents, etc., offer no general solution to us for our aims and objectives differ considerably from theirs.

Plan No. 2

Request the legislatures to create a separate lighting division but in the confines of the architects and professional engineering society. On the surface this plan seems workable. However, changes in bylaws and the general overhauling of the society would be necessary. Assuming that successful pressure was applied and eliminating the controversial atmosphere that it might create, it would still not solve our basic problem of clear-cut recognition for the intent of the society as it was originally set up would inherently remain an association for professional engineers and architects. Our desire is an organization that represents lighting individuality independent of all others.

Plan No. 3

Delegate the Illuminating Engineering Society as our sole representative to act identically for its members as the professional societies do for theirs. State's recognition and endorsement would be requested. Getting this should not be difficult, for the Illuminating Engineering Society through its Sections and Chapters now is the lighting industry's only state's representative.

FOR YEARS the Illuminating Engineering Society has been the champion of lighting. Its governing boards have been judicious, enterprising and a symbol of leadership. It coincides exactly with our ideals for an organization with lighting individuality. The Illuminating Engineersing Society with its already operating study clubs could very well complete the final task of conducting examinations and awarding diplomas.

The condensed plan would be as follows:

Student and associate members could on a voluntary basis enroll in a prescribed study club supervised by an appointive board and the educational director of the I.E.S. Section who would also be the state's representative. Successful completion of the course would establish eligibility for a full I.E.S. membership and a master's illuminating engineer's diploma. The board could designate a period of waiting between enrollment and finishing dates. Practical lighting engineers with proven service would be granted a full membership and diplomas at the board's discretion. Present full members would be granted diplomas on request. This plan would consolidate our aims and welfare into the hands of an institution whose interests are paramount to our own objectives.

IN THE comparatively few years since the introduction of fluorescent lighting, the industry has come a long way but it still requires careful guidance if it is to reach the pinnacle that we hope it will.

PLAN 3, therefore, closely meets the ideal solution for us. It specifies training on a voluntary basis, corrects fallacies now in operation, and guarantees to those who wish to succeed an ultimate reward.

THE THOUGHTS which I have expressed are my personal ones. I do not mean to reflect or criticize the efforts of others for every sound contribution helps in some way to make our jobs better and the final reward will be forthcoming to us with a satisfaction that the industry has improved with our aid.

G. M. KAMMERER
Division Lighting Supervisor
Wisconsin Public Service Corp.
Wausau, Wisc.

Figure 1. Night view of Greater Pitsburgh Airport showing the illumination of the loading apron in front of the south dock (at left) looking out toward a parked airplane. Steel drum is in approximate position of parked plane.

Lighting the Loading Apron At Greater Pittsburgh Airport

By DAVIS H. TUCK

OUTSTANDING lighting design is a most effective feature of the new Greater Pittsburgh (Pennsylvania) Airport, opened this past year. Excellent lighting results were achieved through the planning of their consulting engineer, James Paul Warren, and executed by five Pittsburgh electrical contractors under his careful supervision. The highway approach, public parking lots and covered driveway entrance are all worthy of inspection, as a guide for similar installations.

For the loading aprons, an entirely new technique has been employed, which in practice is proving especially effective. Illumination of these large open areas is usually associated with hazardous glare and elongated sharp shadows both annoying and dangerous. These problems have been mitigated very considerably at the Greater Pittsburgh Airport, through the use of the systems described here.

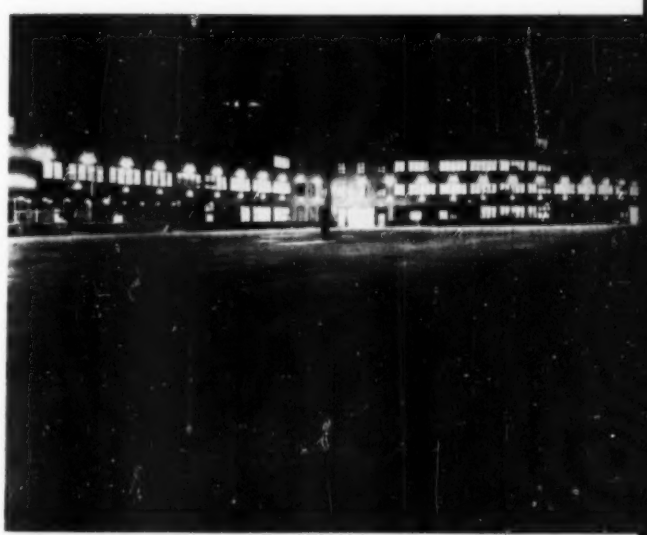


Figure 2. Same area as Fig. 1 except as seen by a passenger landing from an airplane. Note locations of upper and lower rows of asymmetric lens luminaires recessed in the building.

AUTHOR: Consulting Engineer, Holophane Company, Inc., New York, N. Y.

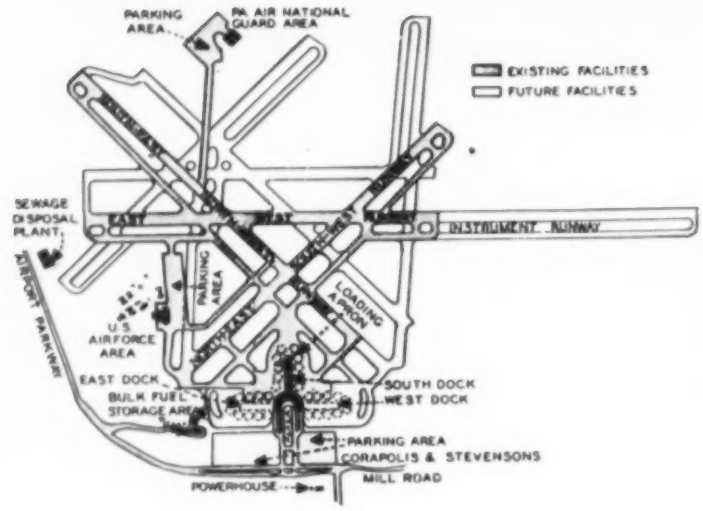


Figure 3. (left) General layout of landing strips, loading docks, terminal building, parking lots, entrance parkway and covered roadways at the new Greater Pittsburgh Airport.

Figure 4. (right) Section through the loading apron and loading dock showing the location and the vertical and lateral candlepower distribution curves of the lens luminaires.

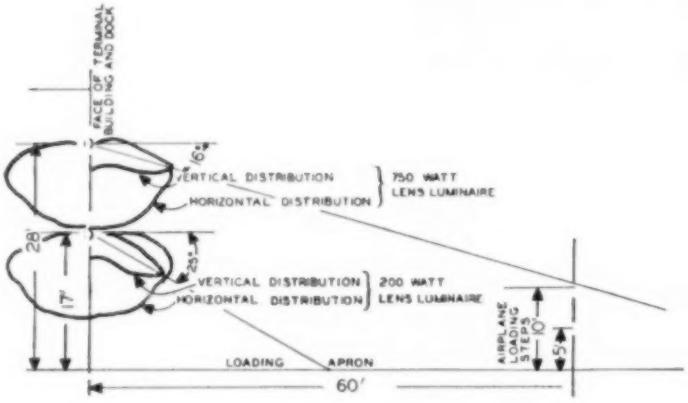


Figure 5. (below) Sectional drawing of the 750-watt asymmetric lens luminaire used at the 28-foot elevation.

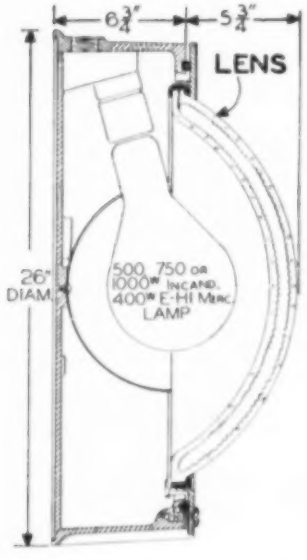


Figure 6a. (below) Sketch of terminal building showing location of the 750-watt upper (28-foot elevation) row and 200-watt lower (17-foot elevation) row of asymmetric lens luminaires used for illuminating the loading apron space between the south dock (at right) and the parked airplane.

Figure 6b. (above right) Close-up of the 750-watt lens luminaire with visor in place, used at the 28-foot elevation.

Glare and sharp shadows have been controlled by relatively close spacing, 18 feet on centers, of wide lateral-spread asymmetric lens luminaires. Those using the larger lamps (750-watt) are mounted high (28 feet) above grade, while those using smaller lamps (200-watt) are mounted lower (17 feet) above grade. The general appearance of the illuminated area is shown in Figs. 1 and 2. Location of the east, west and south loading docks and their relation to the terminal building and loading apron is shown in Fig. 3.

The approximate distance from the loading dock to a parked airplane is 60 feet. It is most important that adequate horizontal and vertical illumination be secured out to this distance. Moreover it is also important that adequate vertical illumination be provided on the portable loading steps up above the apron to a height of about ten feet. At Pittsburgh, the measured illumination on the steps of a parked plane 60 feet out from the loading dock and ten feet above the apron was five footcandles.

This apron illumination is provided by recessing lens luminaires, with 200-watt lamps, in the wall at a height of 17 feet above grade with the angle of maximum candlepower set for 25 degrees below the horizontal, and lens luminaires with 750-watt lamps recessed in the wall at a height of 28 feet above grade with the angle of maximum candlepower set for 16 degrees below the horizontal. The luminaires are equipped with visors to prevent light flux above the horizontal from annoying the airplane pilots. These luminaires are spaced on 18-foot centers, in this installation. Fig. 4 is a section through the loading apron and dock showing the arrangement of the units. In similar applications, 1000-watt incandescent or 400-watt E-H1 mercury lamps could be used with the lens luminaires instead of the 750-watt and 200-watt lamps used in this installation.

Fig. 5 shows a section view of the asymmetric lens luminaires for the 750-watt lamp. The luminaire for the 200-watt lamp used at the lower elevation is of similar construction. This illustration does not show the visor in place but the small photograph in Fig. 6b shows the visor. These units are recessed in the building walls and are hinged for easy maintenance.

Fig. 6a is a daylight view of the south loading dock and loading apron and a quadrant of the terminal building, indicating the location of the upper and lower rows of lens luminaires. Fig. 6b is an enlarged view of one of the luminaires, with visor in place, at the 28-foot elevation.

Fig. 1 shows a night view of the south dock (at left) and a quadrant of the terminal building and the loading apron illumination, looking out toward a parked airplane which will be about 60 feet from the edge of the dock. The steel drum in the photograph indicates the approximate position of a parked airplane. Fig. 2 is the same location except looking in toward the south dock and a quadrant of the terminal building. The first picture (Fig. 1) shows the illumination effect as a passenger walks from the south dock to a parked airplane; the second (Fig. 2) the illumination effect as a passenger walks from a parked airplane to the south dock.

Measurements were made with a model No. 756 Weston footcandle meter at ten-foot intervals from the loading dock out on the loading apron, and the results are given in Fig. 7. Both horizontal and vertical footcandles were measured at grade level.

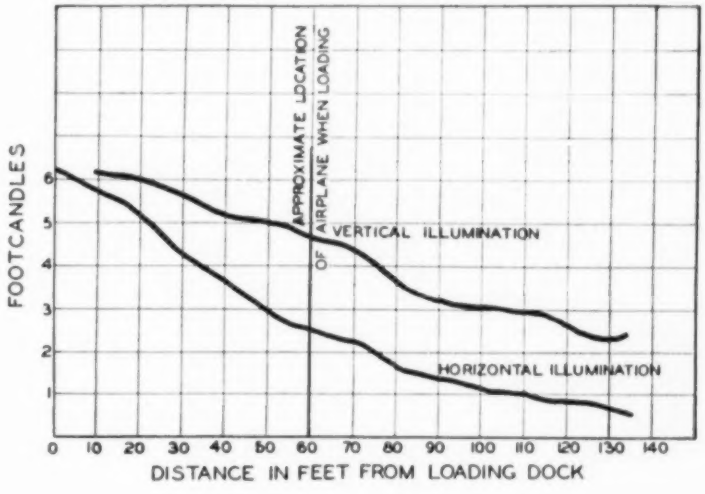

FOOTCANDLES
APPROXIMATE LOCATION OF AIRPLANE WHEN LOADING
VERTICAL ILLUMINATION
HORIZONTAL ILLUMINATION
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
DISTANCE IN FEET FROM LOADING DOCK

Figure 7. Horizontal and vertical illumination measurements from rail of south dock out on the loading apron, made at grade level. Measured vertical illumination on the steps of a parked airplane 60 fet out from the loading dock and 10 feet above the apron was five footcandles.

A New Daylighting Survey Technique Utilizing A Photographic Recorder and Physical Brightness Meters

By W. H. BILLHARTZ
H. F. KINGSBURY
R. W. McKINLEY

I

CAREFULLY conducted daylighting surveys require a different technique from that ordinarily used in making electrje lighting surveys. To present a reasonably adequate picture for design evaluation and comparison, daylighting surveys should usually be made under three conditions:

1. Clear Day — No Sun on Fenestration
2. Overcast Day
3. Clear Day — Sun on Fenestration

Interior illumination and brightness vary considerably and, for the most part, in direct proportion to the exterior illumination on the fenestration. They are affected by the ratio of fenestration area to floor area and, to a marked degree, by the interior surface reflectances.

In a daylighting survey the exterior conditions are constantly changing and so is the amount and distribution of light falling on the fenestration. It is therefore desirable to conduct a daylighting survey in as short a time as possible so that each reading made will be for the same exterior conditions.

Daylighting surveys have generally been made by the manual method in which readings of illumination and brightness at various stations are made one after the other, using one footcandle meter for all illumination stations and one brightness meter for all brightness readings.

Another footcandle meter has sometimes been used to measure outside illumination. There seems to be little general agreement on how this outside illumination should be measured. One operator measures incident illumination at 45 degrees, others have used other methods of correlation.[1] However, the most generally recognized method is to measure the exterior illumination in the plane of the fenestration. There is an advantage in using vertical exterior illumination on the fenestration rather than some other method. Rapp and Baker showed better correlation between exterior and interior illumination by using this method.

When the manual method is used, care must be exercised to read the exterior meter simultaneously with each interior meter. Since the exterior light varies with time all readings taken must be reduced to an arbitrarily fixed level of exterior illumination. A carefully conducted survey of this type gives satisfactory results but is very time consuming.

It is difficult, if not impossible, to take useful brightness readings on the Luckiesh-Taylor or Macbeth Illuminometer if the light is varying. Therefore, brightness measurements by the manual method must be taken when the light is nearly constant. This method is not too satisfactory if it is desired to know the interior lighting picture for a given set of conditions — a certain sun altitude and azimuth, for example, since the procedure takes so long (thirty minutes to an hour or more). The conditions, including sun altitude and azimuth usually vary considerably during the time such a manual survey is being made.

The use of a point-by-point recorder offers only partial improvement because the printing point by point type recorder is essentially a scanning device. It reads the various photocells in order, one after the other. If the light falling on the cells is constant, no difficulty is encountered. But if the light falling on the cells is varying in intensity, then the readings are not comparable. These errors can be significant. In addition to actually taking the readings off the strip chart, one has the additional task of trying to pick a set of readings, taken over a period of several minutes, during which the conditions were relatively stationary.

In an effort to overcome the difficulties described above, The Pittsburgh Corning Daylighting Research Center has developed a photographic recorder for use in making daylighting surveys. When using this photo recorder, stable barrier layer cells are set up at each illumination station and at each brightness station. At brightness stations the cells are so oriented as to measure the illumination falling on the surface. Since reflectances of all surfaces are taken with the Baumgartner Reflectometer, the brightness is obtained by multiplying illumination by reflectance. The brightness of the fenestration is taken with the PC physical brightness meter.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-12, 1952, Chicago, Ill.
AUTHORS: Pittsburgh Corning Corp., Port Allegheny, Pa., and Pittsburgh, Pa.

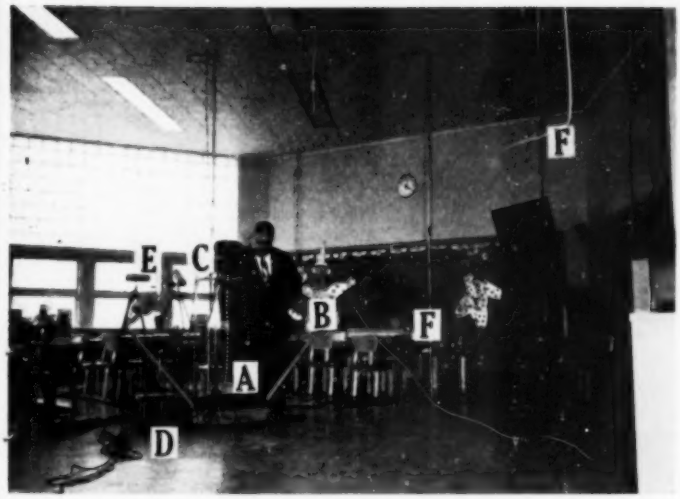


Figure 1. Photo Recorder set up in classroom at Stockton School, East Orange, New Jersey: A. Illumination and brightness meter panel, B. Flash lamp, C. Camera, D. Timer, E. Physical brightness meter, F. Photocells.

All of these cells are connected to micro ammeters assembled on a meter panel. These meters are illuminated with a strobe flash unit and photographed with a camera mounted so as to include all the meters (Fig. 1). Weston Photronic #856RRV cells were chosen for use with this equipment because of their stability. These cells are hermetically sealed in a helium atmosphere, and are, therefore, not affected by humidity changes and chemical contamination which are the main causes of cell drift. The helium and metal case insure good temperature control so that it is no problem to keep them below the maximum recommended temperature of 140F even when exposed for several hours in the sun. This type cell is furnished with a "viscor" filter which corrects the response of the cell so that its spectral sensitivity is very close to that of the human eye. Weston does not, at present, supply the hermetically sealed cell with a cosine corrector.[2] The #856RRV cells are corrected with cosine cor-

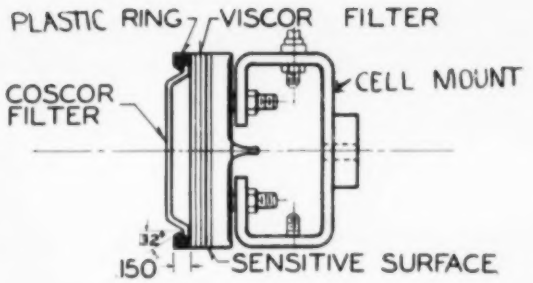
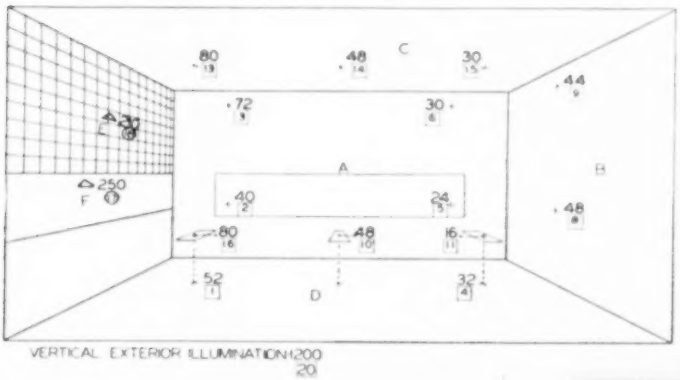


Figure 2. Section through photocell showing arrangement and dimensions of special cosine corrector, holding ring and cell mount.



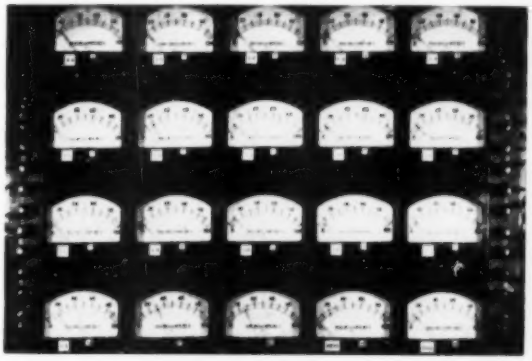
+ 12 METER READING CORRECTED TO FOOTCANDLES

[2] ILLUMINATION METER NUMBER

△ 210 BRIGHTNESS IN FOOTLAMBERTS

(18) BRIGHTNESS METER NUMBER

Figure 3. Results of Typical Room Survey. Illumination values shown on perspective were obtained by multiplying each meter reading by its calibration factor. To obtain brightness in footlamberts multiply corrected meter readings in footcandles by reflectance as follows: Area A, 60%; B, 60%; C, 85%; D, 30%. Fenestration brightness values were obtained by multiplying readings of meters 17 and 18 by proper value from calibration curve shown in Figure 4.



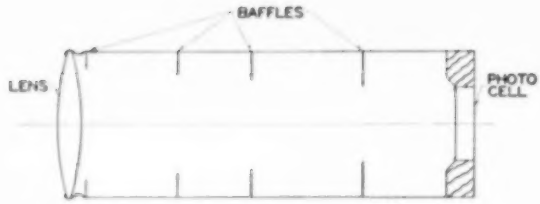


Figure 4A. Section through Physical Brightness Meter.

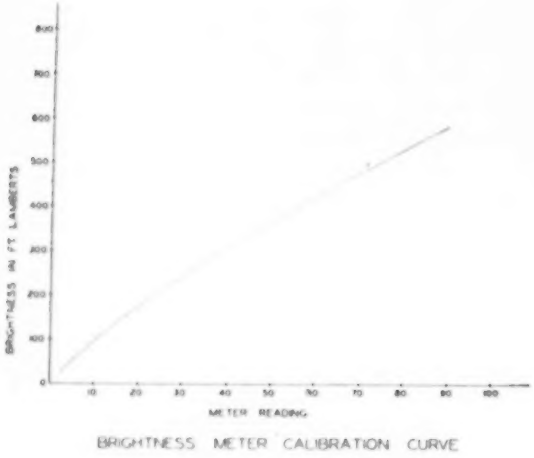


Figure 4B. Typical calibration curve.

rectors intended for use with Weston 594 cells. In addition to the cosine corrector, a small bakelite ring is mounted around the corrector for proper response with the 856 cell (Fig. 2). When exposed to a hemispherical source of uniform brightness, a cell so corrected has an error of less than 1 per cent, while the uncorrected cells have an error of about 20 per cent.

Weston model #741 micro-ammeters with special low resistance movements are used. This particular model meter was chosen because it had the longest scale in proportion to the size of the meter of any readily available. The meters were made up with a resistance of 200 ohms because the Weston 856 cell shows almost linear response, over the range of light intensities used, when its external circuit is 200 ohms or less. The meters have zero to 100 scales and can be calibrated by means of shunts so that the 100 mark represents 10, 100, 500, 1000 etc. footcandles, or to any value within the range of cell sensitivity.

To illuminate the meters for photographing, two Heiland Strob-lights are placed three feet from the meter panel and at 45 degrees from the panel. It was decided to use strob-lights rather than photo-floods because they do not affect the survey meters, provide instantaneous correlation and cause no heat problem.

The camera is a Beattie Portronic camera and is so arranged that an electrical impulse flashes the strob-lights, opens the camera shutter and, after the shutter closes, advances the film for the next exposure. The exposures may be made at any time manually or can be made automatically at fixed intervals by use of a timer. The timer can be set to make exposures as often as every two minutes or at any time interval, in two-minute steps, up to three hours.

The camera uses 70 mm film and takes a picture 2¾ x 3½ inches. This size makes a convenient 3¼ x 4 inch lantern slide when bound between glass plates. It can also be used as a strip film in a lantern slide projector by using a holder to hold the film flat before the aperture. The negatives are projected and the meters are easily read to at least the accuracy one could read the original meter without photographing. If one desires, the negatives may be read with a 6× magnifying glass quite easily and accurately. Prints of any size up to 17 x 20 inches, can be made. Included (Fig. 3) is a photograph made with this equipment.

The equipment uses 20 cells and 20 meters. These cells may be placed around the room as desired making the recorder adaptable to many conditions. The choice of twenty meters used in this equipment does not represent the maximum number usable. Calculations and tests show that with the lens and film used, the meter panel can be expanded to include at least thirty meters, the limiting factor being the resolving power of the lens and/or film.

This photographic recorder offers advantages over other types. With it, it is possible to read the incident light falling on all cells at once. There is no lag between readings of the various cells. With the photo recorder all pictures automatically represent fixed exterior conditions.

Cells can be mounted horizontally or at any desired angle on regular task height tripods and against the wall and ceiling by means of "fish pole" mounts. These mounts consist of three 5-foot tubes which can be telescoped to make them any length from 5 feet to 15 feet. A rubber stopper is used at the top and bottom of the pole to prevent marring the floor or ceiling. The rods are set up vertically and clamped against floor and ceiling. Cells can then be placed at any height desired with the cell face vertical. Wall illumination can be recorded and wall brightness calculated if one measures the wall reflectance. By placing cells with faces horizontal and down at the ceiling, brightnesses of the ceiling can also be obtained.

The PC Physical Brightness Meter used to measure fenestration brightness uses a "photronic" 856 RRV cell mounted at the end of a "telescope" which acts as an optical amplifier. At the other end of the

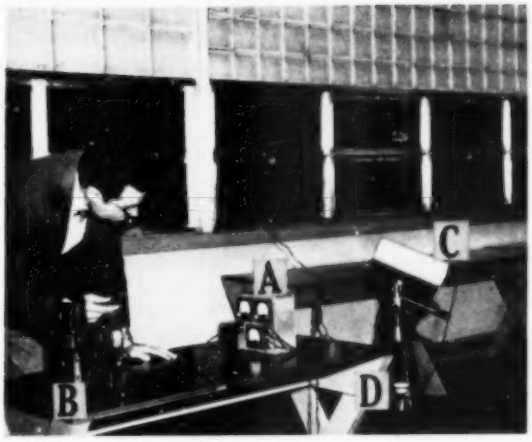
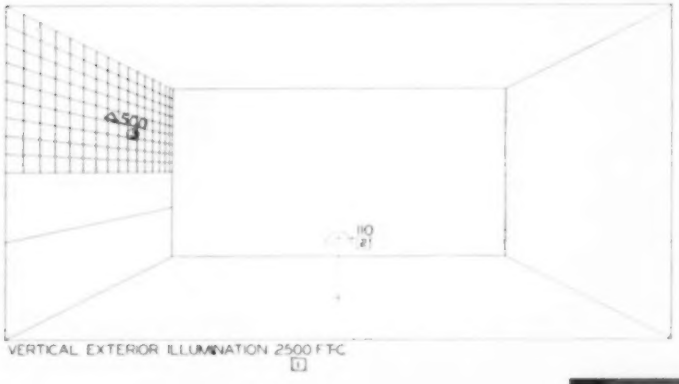


Figure 5. Simplified photo recorder in use at Daylighting Research Center: A. Meter panel, B. Camera, C. Physical brightness meter, D. Photocell.

telescope the objective lens is a 4-inch diameter, 9.84-inch focal length lens which collects the light from the fenestration and focuses it on the photo-cell. The device is so arranged that at a distance of 10 feet the brightness meter looks at an area 2 ft. in diameter. The output of the photo-cell is read on one of the 100 microampere meters on the photo recorder. The brightness meter has been calibrated by pointing it at an area of known brightness and by comparison with a Macbeth Illuminometer. The comparison is good and the meter will repeat its readings within 2 per cent. See Fig. 4.

When it is desired to compare the performance of a certain fenestration with the sun at various altitudes and azimuths it is not necessary to set up the cells etc. for each reading. After the equipment is once placed in the proper position in the room all that is necessary is to take one picture for each light condition.

The importance of reading all illumination and brightness stations simultaneously cannot be over-emphasized. The photo recorder excels in this respect. There is never any doubt concerning the fact that all readings were taken simultaneously and that no change in light conditions took place during the survey. When all readings are not taken



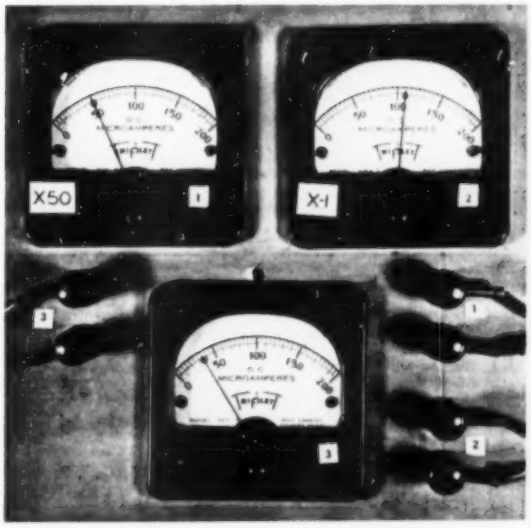


Figure 6. Results of one step in typical room survey using simplified photo recorder. Values are reported as in Fig. 3. Additional values are obtained by moving brightness meter 3 and cell connected to meter 2 to desired positions. Since each pair of interior values is correlated with a simultaneous reading of exterior illumination, they can easily be reduced to a single exterior illumination value and reported on the same perspective.

simultaneously there is the possibility that the light varied between the reading at a certain station and the reading of the outside cell.

II

It is recognized that the investment represented in the photo recorder and accessory equipment is too great for those who have only occasional need for such equipment. For those individuals a simplified version of the photo recorder, which still retains the essential elements and advantages of the larger unit has been developed.

The design basis for this simplified version was to decide what minimum equipment requirements would fulfill the essential needs of an illuminating engineer desiring adequate daylighting data in any room. It would appear that these minimum requirements are: (1) An exterior cell and meter to register incident illumination, (2) An interior cell and meter, to obtain room illumination distributions, and (3) A physical brightness meter for recording surface brightnesses.

After considering all the factors involved, it was decided, as before, to use color and cosine corrected hermetically-sealed photoelectric cells. Although somewhat more expensive than cells without these features, the factors of stability and absence of large errors outweigh the initial cost difference.

Inexpensive, 2 per cent panel microampere meters were chosen for use with these cells.

The physical brightness meter used with this equipment is a modified version of the one described above, in that a "faster" lens, to collect more light, and a lower range micro ammeter, are used to extend to lower levels of brightness the useful range of the device.

The remaining accessories consist of two photographic tripods, one with an adjustable pan head for mounting the brightness meter, the other for the interior illumination cell and a camera to photograph the meter panel.

Almost any small, adjustable focus camera with a flash attachment and possibly a portrait lens may be used for this purpose.

If immediate results are desired, without the bother of film development and printing, a Polaroid Land Camera may be used, if equipped with a flash attachment and suitable portrait lens. See Figures 5 and 6.

With this minimum equipment, it is still necessary to take point-by-point surveys. The brightness meter and/or interior illumination cell is positioned to take a reading at a desired point, the meter panel photographed, the brightness meter and cell repositioned, another photograph taken, and so on, until the entire room is covered to the satisfaction of the operator.

With this minimum equipment, then, one can take point-by-point daylighting surveys, with the advantages of permanent, fool-proof records, simultaneous recording of interior and exterior light, compact equipment, single person operation, entirely physical data, for an expenditure of somewhat under $200.

It is obvious, of course, that set-ups intermediate between this highly simplified version and the large instrument can be made if desirable.

In conclusion, the advantages of this type of instrument are:

1. Completely simultaneous readings of all interior and exterior cells.
2. Permanent, fool-proof records.
3. Completely physical data.

The advice and assistance of Dr. A. H. Baker and Dr. D. D'Eustachio in the development of the photo recorder is gratefully acknowledged. We also wish to express our appreciation to Mr. V. U. Bizzaro, who constructed much of the experimental equipment.

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DISCUSSION

W. J. ARNER*: This paper accentuates one recommendation in conducting daylighting surveys which can not be emphasized too much and that is, frequent determinations of the reference exterior illumination. This rather elaborate technique of making a daylighting survey will certainly

*Libbey-Owens-Ford Glass Co., Toledo, Ohio.

yield results of greater dependability than have been obtained in the past.

However, for the three standard daylight conditions that should generally be considered, daylighting does not have the wide and rapid changes that the authors imply. These rapid changes occur on days with rapidly moving clouds, which is not really one of the three standard conditions. On such a day changes may occur faster than the period of most galvanometers. Since 2- and 4 second periods are quite common for galvanometers, I would like to call the authors' attention to the fact that their recommended technique might yield results that are erroneous as were those obtained in the past. For such days they should still do what others have been compelled to do, postpone readings until more stable conditions are existing.

For their simplified version which calls for the best instruments currently available, and a reading of the reference exterior illumination for every interior illumination reading, I am in complete accord. But, I do not see that the added requirement of taking a photograph of each pair of readings has much to recommend it, especially in light of the limitation due to galvanometer period.

As to the reference illumination, the authors say "There is an advantage in using vertical exterior illumination on the fenestration rather than some other method." This reference has been much used in the past; however, it has a flaw. Consider two identical buildings exposed to the same daylight illumination but with one having a ground reflectance of 16 per cent and the other of 50 per cent outside of the fenestration. Since the light from the ground is directed toward the ceiling, the conditions in the 50 per cent ground reflectance room will be better than for the 16 per cent ground reflectance case. Since the illumination on the exterior vertical surface is greater with the 50 per cent ground, it can and does happen that when adjusting to the same vertical exterior illumination, the 16 per cent case will appear to be better than the 50 per cent case since all values for the 50 per cent case will be divided by a larger value than for the 16 per cent case. This can be seen from Professor Bull's paper (page 25) for Series B runs 8 and 9. For a true evaluation, light from the ground and from the sky should be separately determined and the reference should be illumination on the exterior vertical surface due only to the amount from the sky.

J. W. Griffith*: Daylighting surveys are usually made for the purpose of evaluating an installation or for comparison with other surveys. All conditions must be recorded as well as readings taken within the room before a survey can be used for this type of analysis. It is, therefore, necessary to know the total amount of illumination incident upon the fenestration and what portion of it is coming from the sky alone. Since the accuracy of a survey is dependent upon this information, a more detailed explanation of how this information is obtained in the new daylighting survey technique would be appreciated.

The #741 Weston micro-ammeters appear to be 0-100 microampere meters with 200 ohm movements. If this is the case it seems that greater accuracy could be obtained with shunt resistors and the 0-20 microampere meter of the Weston model #301 type at a lower cost. The lower the range the more accurate the system will be because with the high output RR cells, the microamperes per footcandle is approximately 4.4 ± .3 for the uncorrected cells. With the Viscor and cosine corrector added, the cell output is probably less than 1 microampere per footcandle. Since the per cent accuracy of meters is based upon full scale readings, it is more accurate to take readings on the upper half of the scale. With the 0-20 microampere meter it would be possible to read all readings above 20 footcandles in this portion of the scale, thus producing greater accuracy at a lower cost.

The output linearity of the cell is a function of illumination as well as external resistance and is such that if a low range micro-ammeter is used the external resistance will progressively be reduced by shunt resistors before the higher levels of illumination can be read. It would, therefore, keep the cell on the straighter portion of the linearity curve.

The equipment used in this survey should simplify testing and be far better than the old read and run equipment used in the past. I see no need for the strobe lights, however. If conditions are changing so fast that strobe lights have to be used to stop the meters it seems the test will be of little value anyway.

A suggestion for improvement of the panel is the addition of a calendar clock and a small writing surface so the operator could write in the name of the building, sky conditions, reflection factors, etc.

A good Physical Brightness Meter is something that most people in the field of illumination have hoped for. However, with the meter reported in this paper, care must be taken to include only that area which is being measured in the field of view. The authors report that at 10 feet the meter measures the brightness of an area 2 feet in diameter or more than 3 square feet. This meter appears to be accurate only on fairly large areas of uniform brightness or for average brightness of a large area, while the Luckiesh-Taylor brightness meter allows the measurement of small areas.

W. Glenn Pracejus**: I would like to congratulate the authors on establishing techniques and portable survey equipment to be used in measuring such dynamic conditions as exist in the evaluation of daylighting. While none of the techniques or instruments utilized is basically new, the concept of the physical brightness meter and the use of many light cells in this manner is new.

The physical brightness meter described here views an angle of approximately 11.5 degrees. This is the largest field of view among the many physical brightness meters which have been proposed. Doesn't this large viewing angle make sighting and absolute knowledge of the area viewed difficult? At very short distances, well under ten feet, I doubt that this would be a difficult problem, but I am thinking more in terms of a test distance of more than ten feet and viewing areas such as the vision strip containing division bars. In this case the low brightness of the mullions is integrated with the high brightness of the out of doors.

The individual calibration and identification of a particular cell and meter is not mentioned in the paper. I'm sure that this must be the case and would like to emphasize the need for this identification in any testing which utilizes more than one cell and meter.

W. F. Billhartz, H. F. Kingsbury and R. W. McKinley**: The comments of the various gentlemen are well taken and

*Southern Methodist University, Dallas, Texas.

*General Electric Co., Nela Park, Cleveland, Ohio
**Authors.

their interest is appreciated. It is difficult to develop any instrumentation or method of measuring without some debate as to the best possible means of so doing.

It is true that data should not be taken on days with rapidly moving clouds; however, it is possible to take data with the photo recorder on days when the changes are not rapid enough to fall within the period of the meters but are too rapid to permit use of the manual point by point method.

The period of the meters used is 0.85 second, undamped and in a typical photronic cell circuit 1.5 to 2.0 seconds. However, by using a "T" shunt the period can be brought back to the undamped value.

The purpose in taking photographs in the case of the miniature recorder is to furnish a permanent foolproof record of exterior and interior conditions taken simultaneously.

With reference to Dr. Arner's comments on the effects of ground reflectance there are two pertinent points. In the first place, the interior illumination using light directing glass block is almost independent of the direction from which the exterior light is received whether it be above or below the horizontal. Secondly, we admit that with other types of fenestrations the ground reflection factor may be important, and we suggest that the Daylighting Committee of I.E.S. recommend a standard technique of measuring exterior illumination.

Regarding Mr. Griffith's comment on meter choice, we admit that the #741 meter is more expensive than the #301 20 microampere meter suggested. The #301 meter is a 2 per cent meter while the #741 meter is a 1 per cent meter; and according to information received from the Weston Electrical Instrument Corp. the period of the #301 20 microampere meter is 0.95 second undamped and in a photronic cell circuit shunted to read the 100 microampere is 5 to 6 seconds. With all factors considered, Weston Electrical Instrument Corp. recommended the use of the 100 microampere #741 meter rather than any other meter available.

It was pointed out in the original paper that the strobe lights eliminated the need for blimping the recorder.

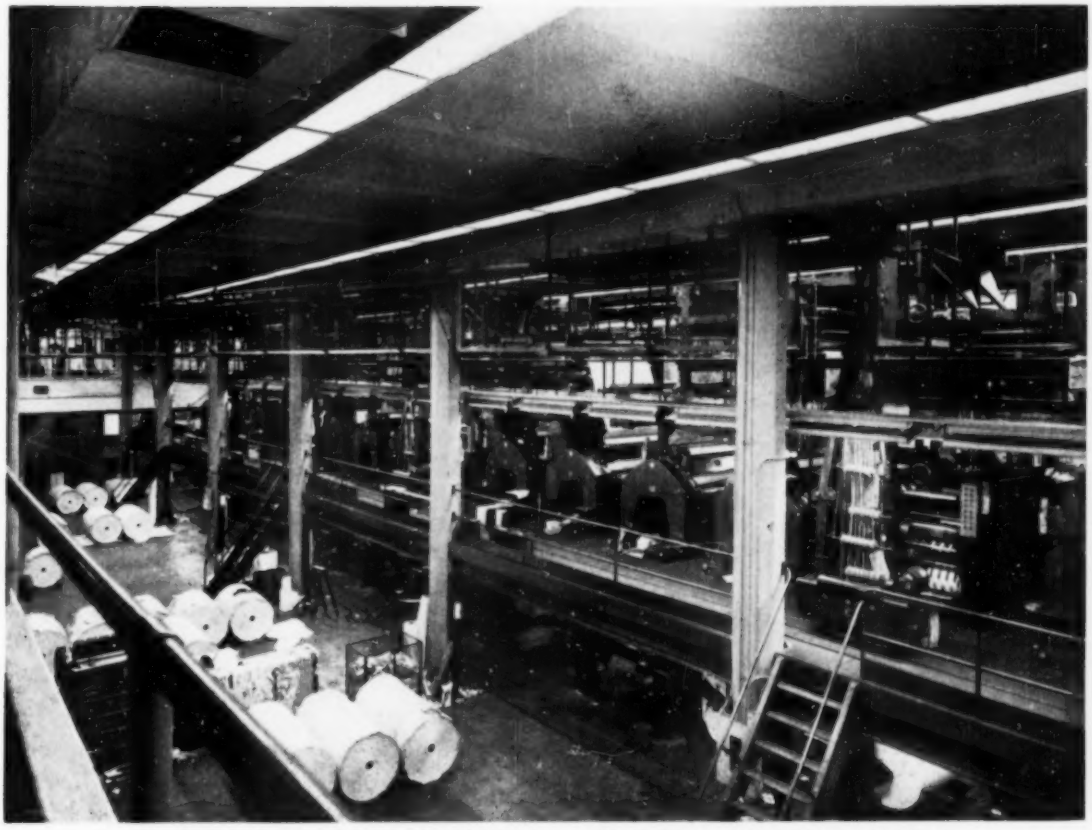
The Physical Brightness Meter was purposely designed to look at the area used. In measuring glass block panel brightness, we want to have an average value for the panel including mortar joints and points of high brightness. In considering the brightness of a wall or ceiling, one generally has large areas to consider, while the Luckiesh-Taylor meter is particularly adapted to measuring the brightness of small areas.

Of course, each meter and cell combination, including lead wire, was calibrated and used as a unit, and each cell, meter and cord bears a corresponding number.

Coves and Spotlights in a Synagogue

An illumination of 10 footcandles is supplied in the pews of the Daily Service Synagogue, Kingsway Jewish Center, Brooklyn, N. Y., by the use of coves and recessed spots. The coves contain white enamel pans carrying two rows of 96-inch T12 standard cool white lamps. Mounted in the ceiling on 7-ft centers are 10 recessed spots, each containing one 150-watt R-40 floodlamp. The synagogue is 36 x 26 ft with a 12 ft 6 inch ceiling. Ceiling is white acoustical material, walls are natural tan wood and gray wainscot, floor is of brown and tan mottled asphalt tile.

Photo courtesy of General Electric Co., Lamp Division, Cleveland, Ohio.



INSTALLATION AT OREGON JOURNAL PRESS ROOM, PORTLAND, OREGON.

Press Room Lighting

LIGHTING OBJECTIVE: To provide three levels of illumination in a room with a large printing press: general illumination, localized general lighting above the pressmen's platform, and localized general below this platform. The customer requested fluorescent lighting equipment with a good maintenance factor, and ease of servicing. The air in the area is permeated with ink vapors.

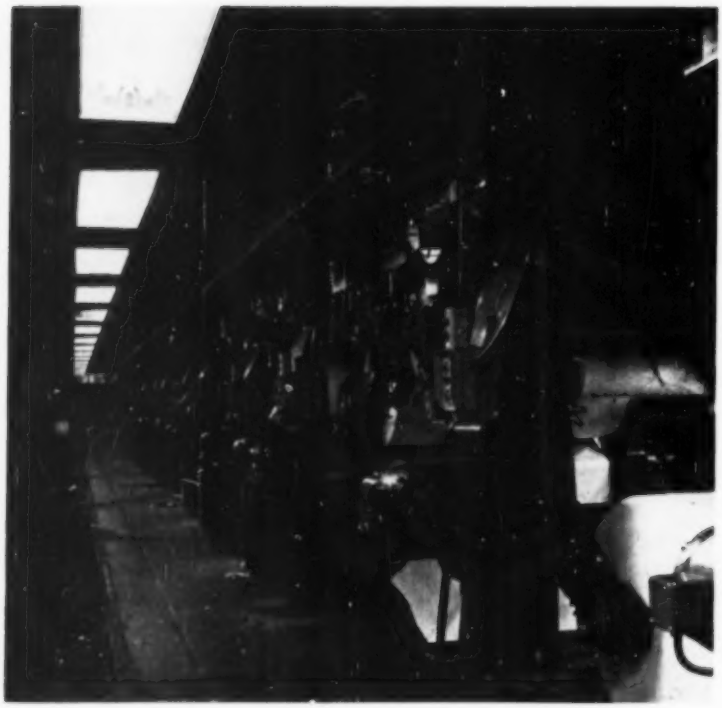
GENERAL INFORMATION: The pressroom measures 73 x 152 feet with a 23-foot ceiling. The ceiling is pale yellow (83% RF), walls are beige (69% RF), columns — salmon (62% RF), press and equipment — dark blue (9% RF), and wooden floors (30% RF).

INSTALLATION: General lighting (45 footcandles maintained in service) is provided by six continuous rows of Benjamin Type E "Lite Line 40" luminaires with No. 8496 hinged dust tight glass covers. Each unit contains three 40-watt white lamps. Rows are mounted alternately 10½ and 14¼ feet apart, 23 feet above the floor.

In addition, there is an almost continuous row (14 8-foot units in 152 feet) of the same type units on each side of the press beneath the pressmen's platform, mounted 7 feet 6 inches above the floor. Mounted 7 feet 6 inches above the platform (15 feet above floor) is a similar arrangement

(over)

A.I.A. File No. 31



Area beneath pressmen's platform.

employing the same type luminaires without covers. The latter units are installed on a special iron channel, tipped 30 degrees up toward the press. (These are each equipped with a short cord and separate plug-in receptacle so that any unit can be easily replaced should this be necessary from a service standpoint.) The localized general lighting produces well in excess of 75 foot-candles on the side of the presses.

Architect: Glenn Stanton, Portland, Oregon; consulting electrical engineers: George Pettingell and Associates, Portland, and William Ginsberg, New York City; electrical contractor: Jaggar-Sraufe Co., Portland.

Lighting data submitted by E. F. McDonnell, Jr., 2762 Hampton Parkway, Evanston, Illinois as an illustration of good lighting practice and to aid in the design of similar installations.

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The Attainment of Quality Daylighting in School Classrooms

By R. A. BOYD

PEOPLE are realizing as they encounter quality in daylighting that it is more a measure of a good visual environment than quantity. This experience is bringing forth recommendations for greater limitations on brightness ratios, especially in school classrooms. Recent action of lighting committees and school code coordinators is reflecting this trend. Although there is this demand for quality in daylighting, published information on how it can be obtained and the importance of related factors is meager. The purpose of this paper is to present information on the quality and quantity of daylighting that is possible through the use of light-directing glass block, the effect of room decoration and the advantages of bilateral fenestration schemes.

Equipment and Measurement

Over a period of ten years the Daylighting Laboratory has experimented with models in the study of daylighting and the results obtained through the use of these models have been compared to corresponding data collected in the full-sized experimental classroom of the Laboratory and in actual classrooms. Studies have been made in which the brightness and transmission data of individual fenestration units were correlated with the complete daylighting result. These comparisons have indicated that the results agree to within five per cent when the model is in scale in all respects.

The results presented in this paper were collected through the use of a one-ninth scale model. This model (Fig. 1) represents a room 30 feet wide, with a ceiling height of 12 feet and depths adjustable to 24 or 30 feet. The equivalent fenestration extended from six feet above the floor to the ceiling and the entire width of the room and consisted of five 8-inch light-directing glass block. This model was used for extensive surveys of the dependence of quality of daylighting upon room surface reflectances; it has removable ceiling, floor and wall panels with reflectances of 6, 10, 16, 28, 38, 49, 62, 77 and 88 per cent. Also, one set of panels was used having the same decoration as the experimental classroom of the Laboratory in order to check the data comparatively. This decoration includes a ceiling drop on all walls, with the result that the average reflectances of the front wall, opposite wall and rear wall are 63, 71 and 77 per cent while the ceiling, desks and floor had reflectances of 88, 48 and 32 per cent, respectively. The reflectances of all surfaces were measured with an integrating-sphere type reflectometer.

In order to have controlled lighting conditions this model was used with the artificial overcast sky that is a part of the Daylighting Laboratory. This overcast sky has the brightness distribution reported by H. H. Kimball[1]; that is, the brightness at the horizon was 0.4 of the zenith brightness and independent of the horizontal angle of view. This sky provided an exterior illumination to the fenestration of 750 footcandles including a ten per cent ground reflection component.

The illumination was measured with a balanced bridge method and corrected photocells[2]; the measurements being made along the centerline of the room at equivalent distances of 3, 9, 15, 21 and 27

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AUTHOR: Research Physicist, Daylighting Laboratory, University of Michigan, Ann Arbor, Mich.

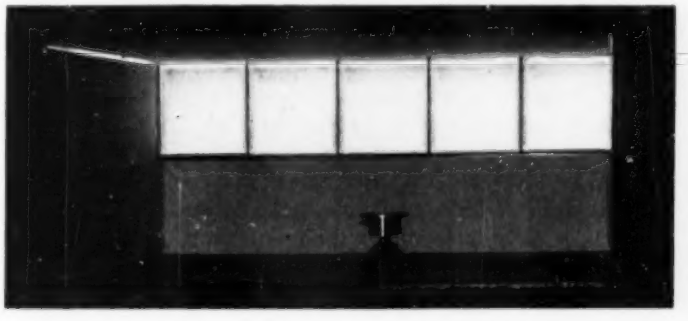


Figure 1. Scale model used for extensive surveys of the dependence of quality of daylighting upon room surface reflectances.

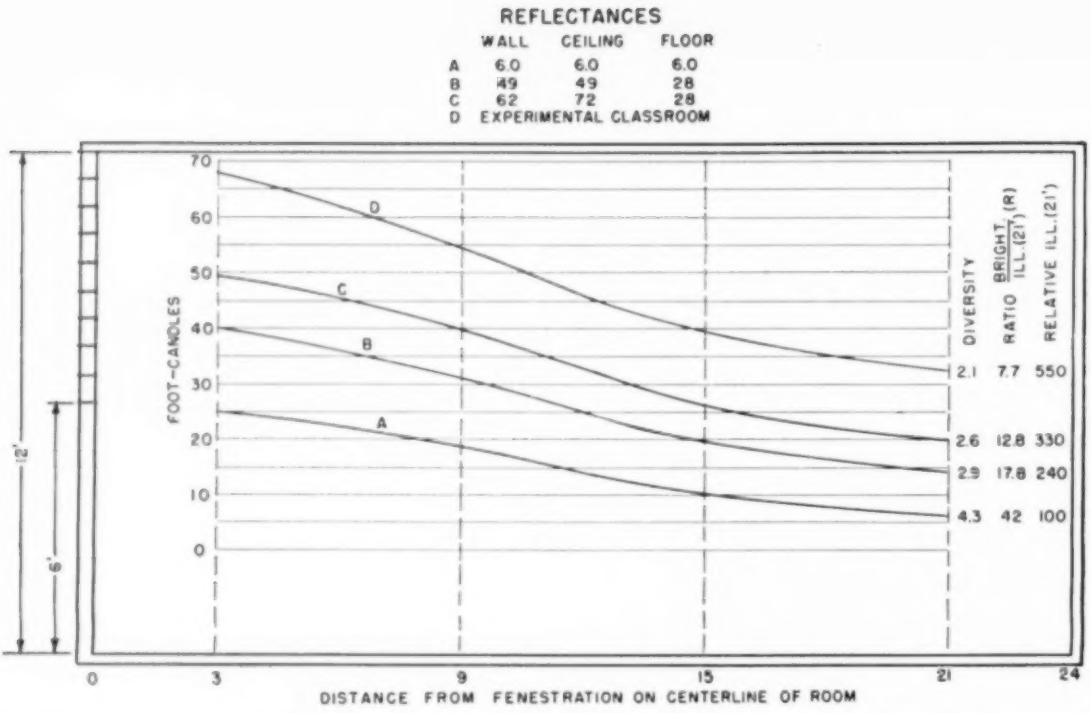


Figure 2. Data for daylighting a classroom using light-directional glass block; room width 30 feet; reflectances as indicated. 1000 ft-c, overcast sky.

feet from the fenestration wall. The head-on or maximum brightness of the fenestration was measured with a direct reading instrument having a field of view sufficiently large to include the entire face of an eight-inch block.

Results

From the theory of surface sources one can easily determine the illumination of a task in a room due to direct light from a luminous wall panel. Numerous charts and tables presenting such data for different fenestration areas and room dimensions have been published.[3, 4] Very little practical information, however, has been published on how the illumination in a room varies when the reflectance of the room surfaces is varied, this being especially true of rooms fenestrated with light-directing glass block. Some data of this type were given in a paper "Glass Block Fenestration and the Interflection Method" presented by Spencer, Stakutis, Kingsbury and McKinley at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C.

Actually in considering quality in daylighting one is principally interested in the maximum ratio of room surface brightness to task illumination.[5, 6] If the interior is properly decorated and the diversity of illumination is low, brightness-ratios throughout the room will be satisfactory. Thus, the major considerations are the ratio of maximum fenestration brightness for the observer to the minimum task illumination and the diversity of the task illumination.

The data collected with the model are presented on this basis in Figs. 2, 3, 4 and 5, for a variety of room surface reflectances and the two room depths. It will be observed that the reflectance combinations are ones that cover the probable decoration of classrooms. The room that is 24 feet deep is somewhat typical of unilateral arrangements while the room that is 30 feet deep will be referred to in a brief discussion of bilateral arrangements.

In considering these data it is convenient to start with all the room surfaces black. The equations that are commonly used to calculate the illumination due to surface sources give the illumination in footcandles when the source brightness is expressed in footlamberts. On this basis the illumination in footcandles due to a uniform hemispherical surround is numerically equal to its footlambert brightness. The factors or ratios of illumination to brightness that apply to the model as used are shown in Table I.

Fig. 2 shows the distribution of light over the

TABLE I.—Ratios of Illumination to Brightness.

	Distance from Fenestration on Centerline of Room				
	3′	9′	15′	21′	27′
Fenestration	0.170	0.109	0.051	0.025	0.014
Remainder of Room	0.830	0.891	0.949	0.975	0.986

working plane, the diversity of the task illumination, the ratio of maximum fenestration brightness to the task illumination at the 21-foot station and the increase of illumination at the 21-foot station due to scattered light in a room that is 24 feet deep for an exterior illumination of 1000 footcandles due to overcast sky. This is the illumination due to light transmitted by the light-directing glass block panel only; the usual vision strip being omitted. These data are presented for four distinctly different decorations.

A consideration of Table I will indicate that the diversity and the ratio R shown by Fig. 2 for the all black room are in good agreement with theory. In the absence of reflecting walls these values would be practically the same for a free masonry opening or for any other type of fenestration material.

The decoration of the experimental classroom has proved to be conducive to high quality daylighting and is considered practical in view of the wide acceptance of lighter finishes for furniture, walls and ceiling.[4] It will be observed that the diversity is only slightly greater than 2, the ratio R is 7.7 and the task illumination 21 feet from the fenestration is 32 footcandles. Equally significant is the large portion of the illumination that is due to scattered light; at the 21-foot station this amounts to 4.5 times the direct illumination. By reference to Table I, it will be noted that the 5.8 footcandles of direct light is equal to 0.025 times the average panel brightness; hence the average panel brightness is 230 footlamberts. The 26 footcandles of scattered light is equal to 0.975 times the equivalent brightness of the remainder of the room above the working plane; hence the equivalent room brightness is about 27 footlamberts. Thus the ratio of average fenestration brightness to equivalent room brightness is only about 8.7. These brightnesses and ratios correspond within five per cent to results obtained by experimental measurement.

These results should be compared to those for a poorly decorated room. Fig. 2 gives corresponding data for a room having a floor reflectance of 28 per

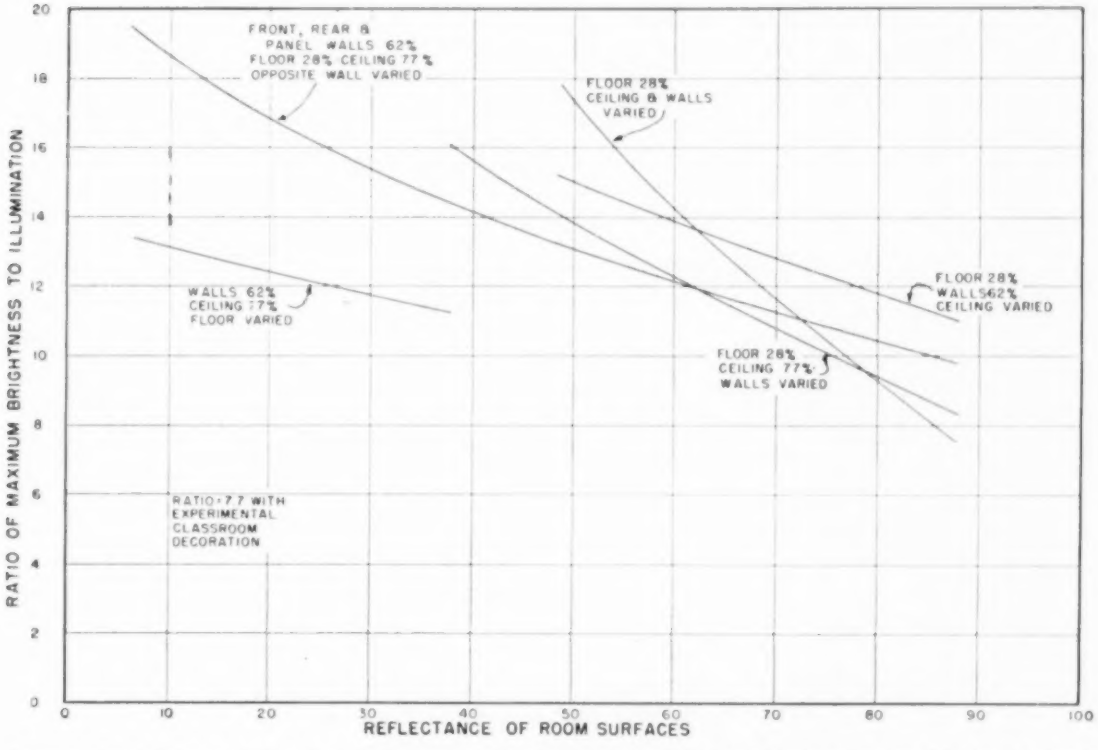


Figure 3. Dependence of quality on room surface reflectance. Light directing glass block; room depth 24 feet; distance to station 21 feet; room width 30 feet; ceiling height 12 feet; sill height 6 feet. Overcast sky.

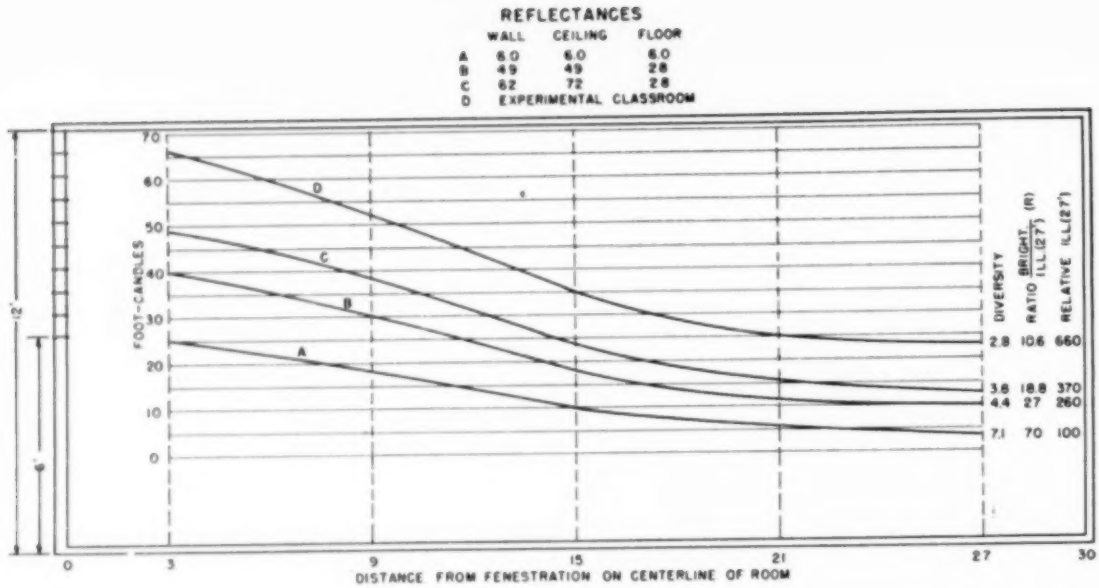
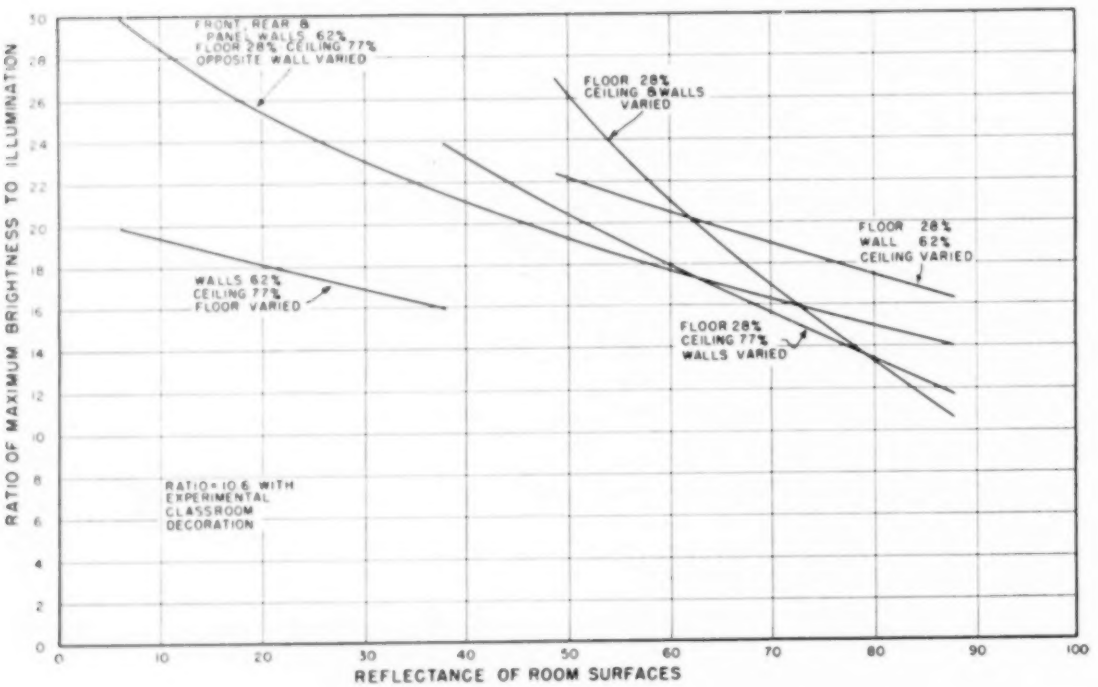


Figure 4. Data for daylighting a classroom using light-directing glass block; 1000 ft-c, overcast sky. Room width 30 feet; reflectances as indicated.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RATIO = 10.6 WITH EXPERIMENTAL CLASSROOM DECORATION
RATIO OF MAXIMUM BRIGHTNESS TO ILLUMINATION
REFLECTANCE OF ROOM SURFACES

Figure 5. Dependence of quality on room surface reflectance; light-directing glass block; room depth 30 feet; distance to station 27 feet; room width 30 feet; ceiling height 12 feet; sill height 6 feet. Overcast sky.

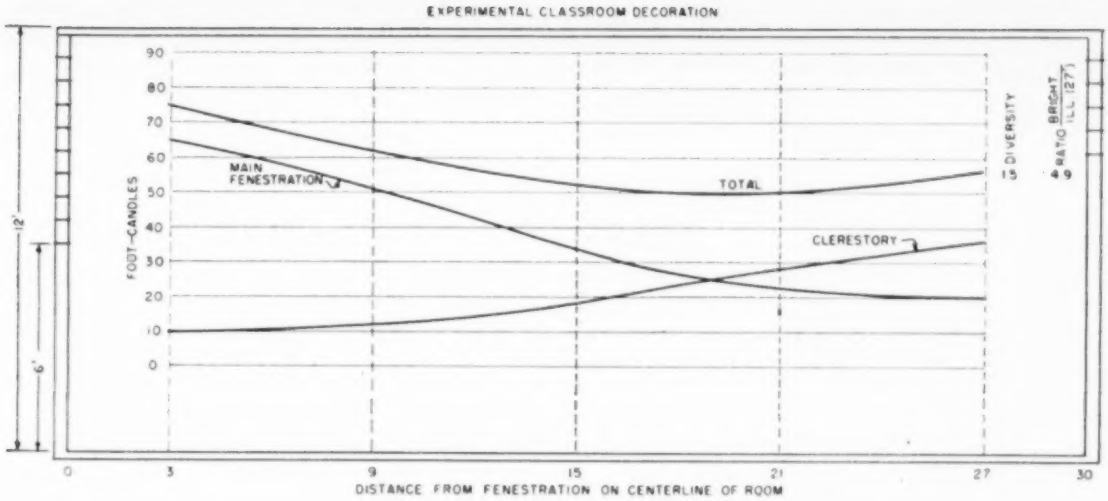

Figure 6. Daylighting a classroom 30 feet deep, decorated similar to experimental classroom and having an opposite clerestory of five courses of light-directing glass block. Exterior illumination is 1000 ft-c from overcast sky.

cent and wall and ceiling reflectances of 49 per cent. Schools are being built today that are this inferior in decoration. In this case the diversity is n t too bad but the ratio of panel brightness to task ilumination is more than twice that for a good decoration. The illumination at the 21-foot station has dropped from 32 footcandles to 14 footcandles and the equivalent room brightness has dropped from 27 footlamberts to about 8 footlamberts. Thus the ratio of average panel brightness to equivalent room brightness is 28 instead of 8.7.

A room having floor, walls and ceiling reflectances of 28, 62 and 72 per cent, respectively, is in common use today and is generally considered to be well decorated; however, Fig. 2 indicates that the daylighting in such a room is somewhat inferior to what can be obtained if greater care is exercised in the selection of finishes.

This loss of quality in daylighting due to poor decoration is true of all fenestration arrangements; it is not only true of rooms fenestrated with light-directing glass block. For any particular decoration higher quality daylighting can be obtained with a fenestration that directs a major portion of the transmitted light onto the ceiling and upper walls for diffuse reflection.

Fig. 3 shows the change of quality for various room surface reflectances. One can observe that for a given change in reflectances of the floor, ceiling and walls the resulting change in quality is the smallest for the floor and the largest for the walls. Frequently in school classrooms the wall opposite the fenestration has a low average reflectance due to cabinets, dark tackboards and light-transmitting areas for admitting light to the corridor. One curve of Fig. 3 shows the loss of quality due to the change of reflectance of the opposite wall.

Figs. 4 and 5 present data for the room that is 30 feet deep similar to those of Figs. 2 and 3. In general, the ratios increase by about 50 per cent due to the increase of room depth of six feet. This definitely indicates the need of a bilateral fenestration arrangement for the deeper room if one is to obtain quality daylighting.

Fig. 6 shows the daylighting of a classroom 30 feet deep, decorated similar to the experimental classroom and having an opposite clerestory of five courses of light-directing glass block; the exterior illumination being 1000 footcandles from overcast sky. It will be observed that the daylighting of this room is superior to that of the classroom that is 24 feet deep and lighted from one fenestration. In addition to the improved daylighting it has several other advantages over the unilateral arrangement. It allows the greater room depth that is needed in modern schools and it assures good daylighting for practically all orientations. A unilaterally-lighted classroom on sun exposure is much better lighted than one on non-sun exposure; thus, in a large school where it is not practical to orient all classrooms the same there is a wide variation of lighting throughout the school. Experience has proven that bilaterally-lighted classrooms on a double-loaded corridor arrangement with east-west exposure are quite satisfactory as regards daylighting. Except for a very short period of time at mid-day, the sun is on either the main fenestration or the clerestory and uniformity of lighting is assured.

TABLE II.—Daylighting Data for Sun and Clear Sky.

Exposure	Date	E.S.T.	Illumination at 21' Station	Diversity	Ratio B/I (21')
South	1/30/52	11:00 A.M.	170 ft-c	2.4	7.9
East	4/7/52	10:45 A.M.	150 ft-c	2.2	8.0
South	4/7/52	11:35 A.M.	200 ft-c	2.4	7.8

This bilateral arrangement was selected as an illustration simply because it has proved to be satisfactory; other bilateral arrangements may be equally satisfactory. When the double-loaded corridor arrangement is used and the two clerestory panels face each other across an open roof there is considerable shading of one panel by the other. In this case it is expedient to provide a light reflecting roof in order to increase the exterior lighting of each panel. Light-directing glass block transmit and distribute the light from ground reflection in almost the same way as light that is incident from above.

All of the daylighting data presented thus far relate to an overcast sky. Studies of daylighting through the use of the full-sized experimental classroom and of models have indicated that light-directing glass block provide the same quality daylighting when the exterior illumination is due to sun and clear sky as when it is due to an overcast or cloudy sky. The distribution of the transmitted light throughout an interior is closely the same for all exterior conditions; the main difference being one of quantity.

Table II shows data similar to those of Fig. 2 for the experimental classroom decoration and for several sun and clear sky conditions as collected with a two-ninths scale model used on the roof of the Daylighting Laboratory.

It is very important in any daylighting arrangement that the fenestration area be sufficiently large for the room. It must be realized that the room illumination is almost directly proportional to fenestration area and that fenestration brightness is independent of area; thus, halving the fenestration area would make the quality ratio worse by a factor of two. This fact is often overlooked today when schools are planned with lower ceilings for economic reasons. In going to lower ceilings consideration should be given to bilateral arrangements in order to utilize the transmitted light more efficiently.

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DISCUSSION

H. S. BULL*: This paper is a noteworthy addition to the technical literature dealing with the light control features of modern glass block used as fenestration material. The author is to be commended for the splendid work he and his research staff are doing in this field.

In my attempt to acquire a more complete picture as to the performance of directional glass block I find there are a few questions which I would direct to the author.

1. What is a typical diversity factor for the "head-on" brightness values over the entire fenestration of your experimental schoolroom for:
(a) Overcast sky approximating the brightness pattern reported by Kimball, and negligible ground reflectance?
(b) Overcast sky of uniform brightness and negligible ground reflectance?

2. I notice that only the experimental classroom (curve D, Fig. 2) with its high interior reflectances meets the accepted requirement of 30 footcandles minimum, and that this was attained with a window wall illumination of 1000 footcandles due to an overcast sky. If we assume a schoolroom with north exposure, and if we exclude localities like Florida, Texas and California, it is my guess that there are very few regions in which such high north sky intensities would be experienced more than 10 per cent of the days during the school season. Does the author have any data bearing on this?

3. In connection with the data shown in Table II, about what fraction of the flux impinging on the fenestration came from below the horizon?

4. I am interested by the statement, in the discussion of bilateral lighting, relative to the behavior of directional glass block receiving light from ground reflection. Does the author have some data giving the quantitative picture as to the behavior of glass block when subjected to (a) well diffused light coming from below the horizon, and (b) strongly directional, reflected sunlight from ground cover?

5. From the aspect of a student seated near the rear of the room and facing the front wall what would be a typical ratio of fenestration brightness to the brightness of the center of the front wall for the reflectances associated with curve C, Fig. 2?

E. W. CONOVER**: In describing model tests the author states that they used a one-ninth scale model but it had full-sized 8-inch glass blocks for the fenestration. Thus it would appear that it is not to scale in all respects but actually represents a full-sized room with glass blocks 72 inches square and 36 inches thick. If this model gave results within five per cent of those obtained in the experimental classroom, then why are the manufacturers of glass block advocating the use of 12 x 12-inch block to get better lighting than the 8 x 8-inch size commonly used?

Dr. Boyd seems to have introduced a new idea by expressing quality as the maximum ratio of room surface bright-

*University of Michigan, Ann Arbor, Mich.
**Detroit Steel Products Co., Detroit, Mich.

ness to task *illumination*. The references 5 and 6 consider the *brightness* of the task for their ratios. Consequently the ratios shown here are not comparable to those of the American Standard Practice for School Lighting unless it is considered that the task reflectance is 100 per cent.

It is stated that the data are presented on the basis of an exterior illumination of 1000 footcandles due to overcast sky. We assume that the author means the illumination on the vertical wall and not that on the horizontal cast by an overcast sky of 1000 footlambert equivalent brightness.

It is interesting to note from Fig. 2 that, although the glass block panel is 25 per cent of the floor area, only the best decorated room will have minimum illumination requirements of 30 footcandles on the desks 21 feet from the window without the assistance of a vision strip. If the exterior illumination of the panel is reduced to 500 footcandles then all desks beyond about seven feet from the window will have inadequate illumination.

We would be interested in seeing a diagram showing how light directing glass block distributes light from ground reflection similar to those that have been published for sunlight from above the horizon.

J. W. GRIFFITH*: The author apparently believes that quantity is not a part of quality. Since quantity is necessary before any brightness ratio can be had I cannot agree with him. If brightness ratios are the more important of quality lighting, then pull the blinds, turn off the artificial light, and work in a good visual environment. I realize the need for comfortable brightness ratios. However, I believe a minimum quantity of light should be obtained on the work plane before the quality of a visual environment could be considered fair and certainly above the minimum before it could be considered good.

The author states that comparisons between the full-sized experimental classroom and models have indicated that results agree to within 5 per cent when the model is in scale in all respects. Fig. 1 shows a model with a fenestration consisting of five 8-inch light directing glass blocks. Does this represent a full-sized room with five glass blocks roughly six feet square and three feet thick? If this model compares within 5 per cent to a full sized test employing 8- or 12-inch blocks that are roughly 4 inches thick, it would appear that there are compensating errors in the tests. The model in effect has vertical louvers that are three feet wide, a three-foot overhang, and a three-foot wide sill that reflects light up to the ceiling in much the same manner that ground light is reflected into a room.

If the overcast sky used with the model has a distribution pattern as stated with 10 per cent ground, then we might assume that 100 to 150 footcandles of the incident light is reflected from the ground. This assumption being based on the fact that the zenith is approximately three times as bright as the horizon and, therefore, produces higher ground brigtness and lower vertical illumination than does a more uniform overcast.

The illumination from the sky alone would then be 600 to 650 footcandles or the amount that would be produced by a uniform overcast of 1200 to 1300 footlamberts. This is 200 to 300 footlamberts brighter than the more generally used 1000 footlambert uniform overcast sky. All the data in Figs. 2, 3, 4, 5 and 6 appear to be for an exterior illumination of 1000 footcandles. Assuming that these data were taken with the same artificial sky and the exterior illumination was measured in the same plane as the fenestration, the amount of illumination coming from below the horizon would be 350 to 400 footcandles. This is what might be expected if the ground were covered with snow. Furthermore, the data are for a room having a six-foot sill. With such a high sill you are cutting off that portion of the fenestration that produces the most light from ground reflection in the interior of the room where it is most needed. Does the author recommend six-foot sills?

The decorations of the experimental room have rather high reflectances on the walls. Since white walls would probably give lower R ratios, does the author consider these reflectances to be the maximum permissible values?

The author states that a unilaterally-lighted classroom on sun exposure is much better lighted than one on a non-sun exposure. Is it not true that the sun exposure produces higher R ratios than does the clear sky exposure with no sun?

J. A. MEACHAM**: It is a common experience in selecting paint to have the customer ask for *darker* colors (40 to 50 per cent RF) on the walls because they are said to be more "comfortable." Many people really feel they get unusual relief by raising their eyes from a well illuminated task to a lower reflectance wall area.

Also in states where sunlight is very strong, some people feel that darker colors on room interiors give a comforting relief from excessive heat and brightness out of doors. Colorists designing school decoration in California, for example, express this view.

On the other hand, Dr. Boyd's data show that lower wall reflectances give poorer quality illumination in the sense that ratios of brightness to illumination are greater. I would ask Dr. Boyd if his work in this field gives him a basis for resolving this apparent discrepancy between (a) the personal preference for darker colors often expressed by our customers on the grounds of greater comfort, and (b) the experimental proof that light colors give better "quality" lighting in terms of low brightness ratios.

R. A. BOYD**: The fenestration of the experimental classroom of the Daylighting Laboratory consists of light-directing glass block. For an exterior illumination of 1000 footcandles due to direct light from an overcast sky these block have an average brightness of 215 footlamberts for an observer viewing them at 0° azimuth and from 20 degrees below the horizontal. I assume that Professor Bull's first question refers to the variation of this brightness over the entire panel. Such a variation would be due to changes in the pressing or manufacture of the block. Manufacture is carefully controlled; brightness difference from block to block is negligible.

As regards the adequacy of the quantity of illumination cited in this paper; the question of how many footcandles of illumination are required for the average visual task when it is associated with high quality is still controversial. It appears quite probable, however, that 30 footcandles is not required for reading except in bad glare conditions.

The use of light directing glass block is not limited to north exposure. They provide substantially the same quality of daylighting for all exposures and for all exterior illumination conditions. Of course, the quantity of interior daylighting varies with the exterior illumination. According to

*Southern Methodist University, Dallas, Texas.

**Sherwin-Williams Co., Cleveland, Ohio.
**Author.

a tentative analysis of the data collected on exterior illumination it appears that the minimum task illumination in a typical 32 x 24 x 12 foot unilateral classroom, with experimental classroom decoration and fenestrated with light-directing glass block, would be above 30 footcandles 75 per cent of the time; assuming a ground reflectance of 20 per cent.

The data presented in this paper were collected through the use of the artificial overcast sky. This arrangement provides a ground reflected component equal to about ten per cent of the total exterior vertical surface illumination. The light directing glass block used in these tests transmit and redirect the ground reflected light in the same way as the direct light from the sky; the room lighting per footcandle of exterior illumination of the panel is about ten per cent less for ground reflected light than for the direct light.

Professor Bull's last question relates to the brightness ratio between the block panel and the center of the front wall for the case represented by curve C of Figure 2. For the student in the rear of the room and near the opposite wall this ratio would be 6.5 to 1.

In using full sized light directing block in the model, the thickness of the block does not introduce an error in the daylighting results obtained because one is only concerned with the distribution of light from the innermost face. This distribution pattern differs from one for the full sized panel only as regards the location of the mortar and the block border. This small difference does not have an appreciable effect on the task illumination since most of the light is multiply reflected from room surfaces before reaching the working plane.

Mr. Conover questions the use of 8 inch and 12 inch block in models. In this work the model scale is adjusted in order that a whole number of block can represent the fenestration; thus different models are used with the two sizes of block. The performance of the 12 inch block is somewhat different from that of the 8 inch block; but, since the actual block is used in the models this difference is taken into account.

The remainder of Mr. Conover's questions have been commented on previously.

Mr Griffith very appropriately brings up the question of ground reflected light and the difference in exterior illumination due to an overcast sky and a uniformly cloudy sky.

The artificial sky at the Daylighting Laboratory is an overcast one having the distribution of brightness reported by Kimball (Recommended Practice of Daylighting—Figure C 7). This distribution has a horizon brightness that is about 0.4 of the zenith brightness. The actual exterior illumination of the model fenestration was 750 footcandles of which about 75 footcandles was due to ground reflection. The data collected in the model were then scaled up to correspond to a total exterior illumination of 1000 footcandles.

According to the data reported by Kimball the exterior illumination in footcandles, of a vertical surface due to an overcast sky is about one-third of the zenith brightness (expressed in footlamberts). Thus, the exterior illumination of 900 footcandles and a horizontal surface illumination of 1800 footcandles. This in order for the ground reflection on a horizontal surface would be provided by an overcast sky having a zenith brightness of 2700 footlamberts and a horizon brightness of 1080 footlamberts. The case reported on would call for a ground reflection of about nine per cent.

A uniformly cloudy sky having a brightness of 1800 footlamberts would provide a vertical surface illumination of 900 footcandles and a horizontal surface illumination of 1800 footcandles. Thus in order for the ground reflection component to be 100 footcandles the ground reflectance would have to be about 11 per cent. From this point of view there is not much difference in the two skies; the big difference, however, is one of brightness. The horizon brightness for the uniform sky is almost twice that of a comparable overcast sky. This is not an important item in the daylighting provided by light directing glass block but it is of extreme importance in the case of non functional fenestration materials.

In view of these differences it appears desirable for those reporting on daylighting to reach an agreement as to the characteristics of a completely cloudy sky.

The decoration of the experimental classroom involves rather high reflectances but the author does not consider them to be too high. If quality daylighting is to be provided one must use reflectances as high as is practical from a maintenance point of view. Completely white walls are not practical and they are certainly not desirable from an aesthetic and a visual comfort point of view.

In reference to Mr. Meacham's comment, it is highly desirable that I find a way of taking into consideration the reflectance characteristics of paint.

The author wishes to express his appreciation to the discussors of this paper for their interest and comments.

New Industrial Lighting Standard

A new American Standard Practice for Industrial Lighting, long-awaited and now with full approval of A.S.A. committees, is now available in 40-page booklet form through I.E.S. Publications Office. While the proposed new practice appeared in ILLUMINATING ENGINEERING some time ago, the new booklet includes all subsequent revisions and is the "last word" for lighting engineers and specialists; architects; consultants, contractors and others requiring detailed information for industrial lighting in all aspects. Single copies are 50c; quantity prices on request.

Dual Light Source in Machine Shop

Daytime machine shop illumination is provided by a combination of daylight, filtered through skylights, and 400-watt fluorescent mercury-vapor lamps. When intensity of incoming daylight increases to 60 footcandles, photoelectric cells switch off lamps; when it drops to 30, lamps are switched on.

By GEORGE P. LEYES

FLUORESCENT mercury-vapor lighting, and daylight filtered through special plastic skylights, provide a general illumination of 30 footcandles maintained minimum day and night, for a new 55,000 square-foot machine shop at the Sunnyvale, California plant of Westinghouse Electric Corporation. A photoelectric relay automatically controls the fluorescent mercury-vapor source as daylight fades. Each machine also has its own incandescent lamp to provide a higher level of illumination on the immediate work area.

The shop is divided into four bays, each 280 feet long by 50 feet wide. A 10-foot aisle runs down the center of each bay, with a row of machines on each side. Two hundred and ten 400-watt fluorescent mercury-vapor (J-H1) lamps mounted in Alzak-processed high bay luminaires are mounted 20 feet above the floor on 12 by 20-foot centers and serve to light the center machine shop area.

The luminaires are wired three per circuit on a three-phase, four-wire, distribution system using 120-volt, 25-ampere branch breakers. Phasing of the circuits is staggered to eliminate stroboscopic effect.

Translucent skylights make up approximately 10 per cent of the roof's area; each 50 by 20-foot section has two 6 by 8-foot green corrugated translucent skylights to provide filtered natural light during daytime hours. These skylights transmit and diffuse 60 per cent of the external light. They also filter out about 65 per cent of the infrared heat rays, resulting in cooler and more comfortable working conditions.

Two photoelectric cells located above the lighting fixtures measure the level of the incoming daylight. When this level falls below 30 footcandles, photoelectric relays actuate contactors located in the panelboards, and automatically turn on the fluorescent mercury-vapor lamps. When the intensity of the incoming daylight increases to 60 footcandles, the mercury-vapor lamps switch off automatically.

To further improve seeing conditions in the shop,

AUTHOR: Lighting Application Engineer, Westinghouse Electric Corporation, San Francisco, Calif.

Machine shop illumination at night is provided by 400-watt J-H1 mercury vapor lamps.

a system of color dynamics is used. All machines are painted in contrasting shades of yellow, green, orange, and buff to provide a more pleasing background, maintain comfortable brightness ratios, and aid in increased safety. Each machine tool carries a basic color of light green, with buff to identify the control arms. Operating levers are yellow, and electrical controls are orange. The walls and ceilings are painted shop white with a green wainscoting extending four feet above the floor. Floors are light-colored concrete. Ceiling and wall reflection factors are 50 and 30 per cent respectively.

High-Level Lighting in Library Reading Room

The main reading room in this library is 49 x 145 ft with ceiling height of 19 ft 10 inches. The lighting installation was designed to be a component part of the acoustical tile ceiling providing adequate illumination and an atmosphere quiet and conducive to study.

Recessed troffers with diffusing glass closures contain 96T12 slimline lamps operating at 425 ma. After 30 days of operation the illumination level was 95 footcandles.

The walls of the reading room are painted cream buff; trim is Wedgewood blue; table tops are of bleached birch and floors of marbelized rubber tile. Brightness readings after 30 days of operation were: Troffer glass at 30 degrees longitudinal, 410 ft-L; ceiling between troffers, 15 ft-L; side walls and table tops, 35 ft-L.

This installation won first place for Mrs. Winifred Erdle, Beman and Candee, Consulting Engineers, Buffalo, in the 1952 "My Most Interesting Lighting Job" contest conducted by the Western New York Section, I.E.S.

Controlling and Redirecting Daylight By Means of Louvers

By HEMPSTEAD S. BULL

Results indicate that both horizontal and vertical louvers may be used advantageously in northern exposures. Slightly tilted horizontal louvers distribute the daylight better while vertical louvers well control the brightness. A horizontal louver system with two or more angles of tilt offers a good possibility.

IN THE procedure described, a scaled model of a typical schoolroom was set up and exposed to simulated skylight and sunlight of various brightness patterns. For each chosen sky composition the effects of various louver arrangements in the window opening on the brightness and footcandle levels within the room were accurately measured.

The Model Room

The "typical" schoolroom was 32 feet long and 24 feet wide, with a 12-foot ceiling. The window opening on one of the long sides was 30 feet long, extending to within 6 inches of the ceiling and with a sill height of 3½ feet. The work plane height was 27 inches. The front wall and the side wall parallel to the windows had black chalkboards. The model room, constructed of masonite sheets, embodied this dimensional plan to ¼ scale.

Fig. 1 shows the interior of the model room, with the cosine-corrected photocell employed in measuring work plane footcandles shown in the background. Because of the wide-angle lens used on the camera considerable distortion is present. The vertical louvers were actually all at a uniform angle of 40 degrees between the plane of the louver and a plane perpendicular to the window wall.

The model room surfaces were painted to give the following reflectances: ceiling, 80 per cent; walls, 50 per cent; floor, 25 per cent; chalkboard, 10 per cent.

The Artificial Sky

Fig. 2 shows a portion of the sky vault used to simulate natural light from an overcast sky. The window wall of the model room was parallel to the masonite partition shown on the left of the photograph and slightly to the right of the right-hand edge of the picture. The tracing vellum overhead was illuminated from above by an assembly of light boxes, each containing a 40-watt white fluorescent tube. The reflector floods shown on the floor were used to build up the brightness levels above the horizon line to the desired values.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-12, 1952, Chicago, Ill.
AUTHOR: Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich.
Work done under Research Fund Project #2.

Observation Stations

For the determination of the illumination pattern at desk-top height 48 stations on one-foot centers were marked out on the floor of the model.

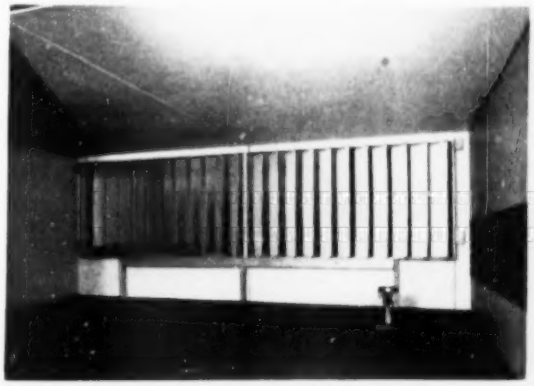


Figure 1. Interior of model room, with the cosine-corrected photocell employed in measuring work plane footcandles shown in background.

Figure 2. Portion of the sky vault used to simulate natural light from an overcast sky.

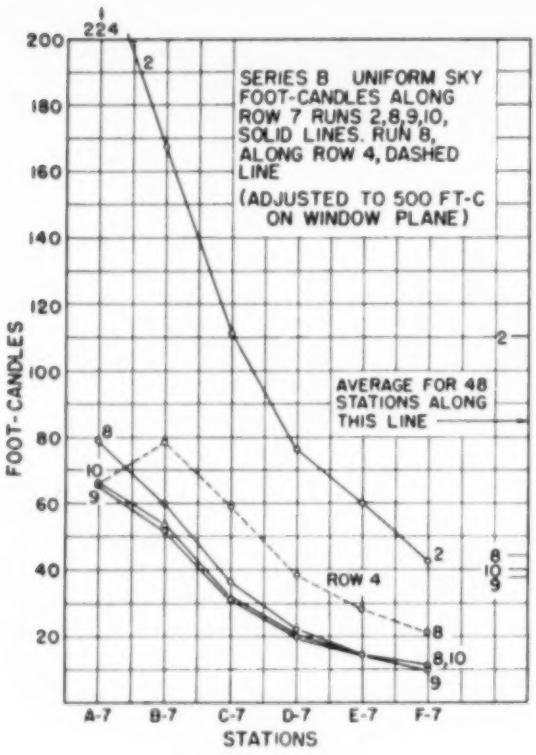


Figure 3.

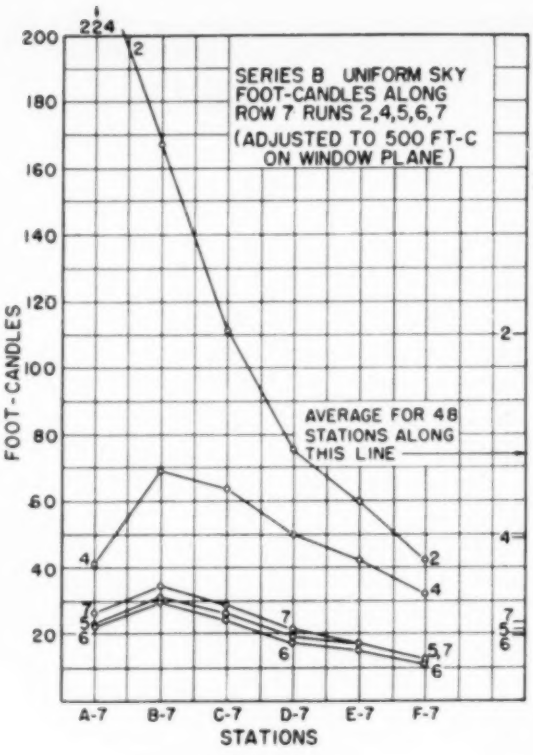


Figure 4.

Brightness readings of a few spots on each wall and 20 uniformly spaced spots on the ceiling were obtained by sighting with a Macbeth Illuminometer through convenient apertures.

Series A Tests

A non-uniform sky brightness pattern was used in this series, the horizon brightness being about 33 per cent of the zenith brightness. Space restructions prohibit a discussion of the results here.

Series B Tests

For this series the artificial sky was adjusted to a condition of approximately uniform brightness from the zenith to the horizon. Of the 10 runs taken in this series, only those of special interest will be discussed here. See Figs. 3 and 4.

Run 2. No glass or control devices were introduced in the window wall. The foreground had what is termed as the standard reflectance of 16 per cent. Fig. 3 shows a plot of the footcandles observed along a line of stations running perpendicular to the window near the rear of the room, and adjusted to an assumed illumination of 500 footcandles received on the sill in the plane of the window.

Run 4. A set of frames with grooved sides was placed in the window wall opening and horizontal louvers composed of sheet metal rectangles were supported therein. The vertical distance between the axes of the louver blades was 4 inches and the depth of each blade 5 inches. Both blade surfaces were painted white. In this run the angle of tilt was 0 degrees, that is the louvers lay parallel to the horizon plane.

Run 5. The angle of tilt was 40 degrees. No other change was made.

Run 6. The only change from Run 5 was the introduction of a vertical sheet of window glass just outside the louver system.

Run 7. The glass was removed and a temporary foreground of 50 per cent reflectance was laid on the floor of the sky vault. The louver tilt was still 40 degrees.

Run 8. A set of vertical louvers was substituted for the horizontal louvers and tilted 40 degrees. The foreground was standard.

Run 9. Same as 8, with glass inserted.

Run 10. The glass was removed and the 50 per cent reflectance foreground used again.

Series C

In preparation for this series a battery of deeply hooded projector spots to simulate direct sunlight was substituted for the diffuse sky structure. The angle between the rays and the window plane ap-

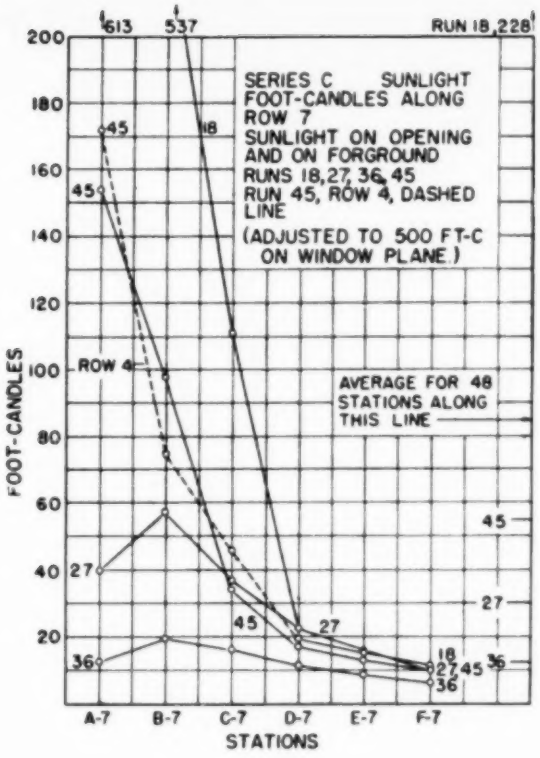


Figure 5.

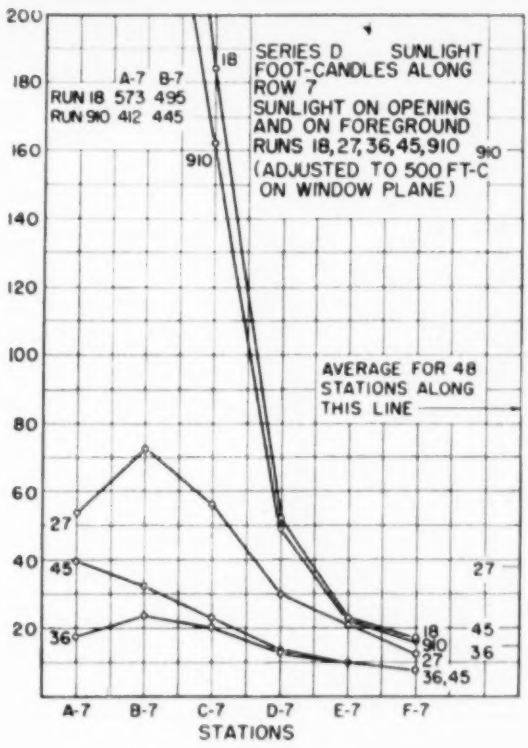


Figure 6.

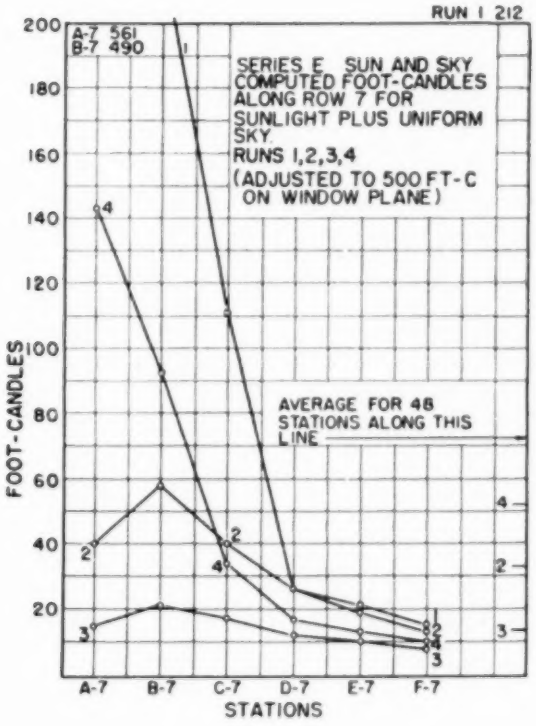


Figure 7.

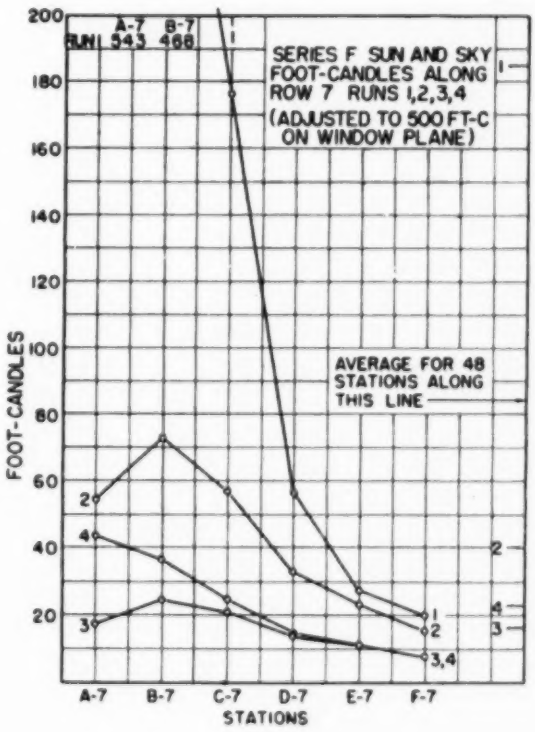


Figure 8.

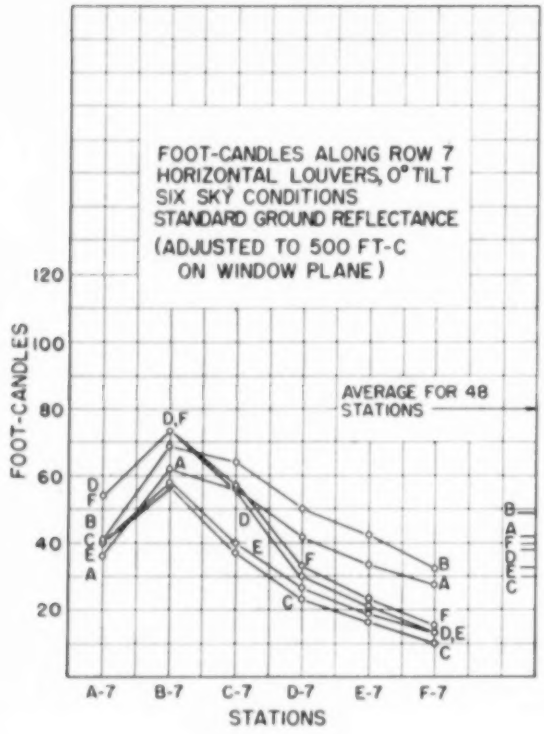


Figure 9.

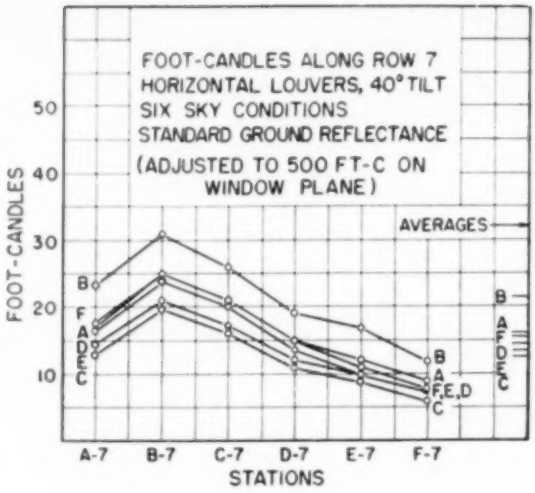


Figure 10.

proximated the conditions of a southern exposure to noon sunshine in March at 40 degrees N. Latitude.

Footcandle and brightness surveys were made under four conditions: Run 18, the bare opening; Run 27, horizontal louvers tilted 0 degrees; Run 36, horizontal louvers tilted 40 degrees; Run 45, vertical louvers tilted 40 degrees. The standard foreground was used. See Fig. 5.

Series D

The mounting arrangement of the projector spots was altered to simulate direct sunlight late on a March afternoon for the same room exposure and latitude. The effects of these more slanting rays were studied under five conditions: Run 18, the bare opening; Run 27, horizontal louvers tilted 0 degrees; Run 36, horizontal louvers tilted 40 degrees; Run 45, vertical louvers tilted 40 degrees; Run 910, glass in opening, no louvers. The standard foreground was used. See Fig. 6.

Series E

It was not considered feasible to simulate in actual tests the combined effect of sun and sky. Instead it was proposed to multiply all data of Series C by a factor obtained by making the assumed window plane illumination in that series seven times* the corresponding figure for Series B, and then adding the adjusted data of all runs in C to the comparable data of Series B. The results thus obtained, while obviously inaccurate, certainly can be used to indicate the general behavior of sun plus clear sky. Fig. 7 shows the results of this combination for four conditions: (1) the bare opening, (2) horizontal louvers tilted 0 degrees, (3) horizontal louvers tilted 40 degrees; (4) vertical louvers tilted 40 degrees. All were with the standard foreground.

Series F

The same general procedure was followed in combining the sky data of Series B with the sunlight data of Series D, except that the sunlight data were weighted eight times the sky data to correspond more nearly to late afternoon conditions. Fig. 8 shows the results of this combination for the same four control conditions listed under Series E.

Discussion of Results

Figs. 9, 10, 11 show the behavior of horizontal louvers for two angles of tilt and vertical louvers for one angle of tilt under six sky brightness patterns.

When horizontal louvers with 0-degree tilt were used the average workplane footcandles became 35 per cent to 45 per cent of the average for the bare opening for the diffuse sky tests and 13 per cent to 21 per cent of the bare opening results for the tests involving sunlight. The corresponding percentages observed at a station near the rear corner farthest from the window wall were 70 to 76 for the diffuse sky tests and 80 to 88 for the tests involving sun-

*I.E.S. Lighting Handbook, first edition, p. 92.

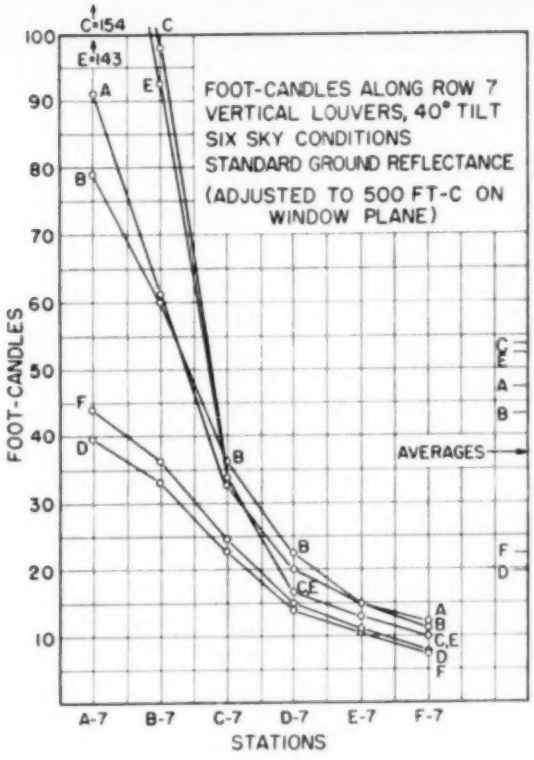


Figure 11.

light. Thus stations far removed from the window are penalized very little by the introduction of horizontal louvers with 0-degree tilt. Furthermore the departure of any station reading from the average for that run is not very great.

When the horizontal louvers were tilted 40 degrees the average workplane footcandles became 13 per cent to 20 per cent of the average for the bare opening for the diffuse sky tests, and 5 per cent to 9 per cent for the tests involving sunlight. The corresponding percentages observed at a station remote from the window were 23 to 28 for the diffuse sky and 40 to 55 for the tests involving sunlight. This indicates that a 40-degree tilt is too extreme; there is too much reduction at all stations.

With vertical louvers tilted 40 degrees the average workplane footcandles was 38 per cent to 40 per cent of the average produced by the bare opening for the diffuse sky tests and 10 per cent to 25 per cent for the tests involving sunlight. The corresponding percentages observed at a station remote from the window were 26 to 30 for the diffuse sky and 42 to 87 for the tests involving sunlight. The observed variations in illumination along a line perpendicular to the window plane are much greater than was the case for horizontal louvers.

A few of the most significant brightness ratios have been tabulated for many of the test runs. The ratios indicated were those coming well within the visual angle of an occupant seated near the window about midway between front and rear walls, and facing the front chalkboard. It will be noted that the lowest ratios were associated in every case with vertical louvers. Of course all of the tabulated ratios could have been greatly improved by the use of lighter chalkboards; extremely unfavorable conditions were deliberately chosen for these tests.

The results obtained in the tests with high-reflectance foregrounds require careful interpretation. If comparisons are made on the basis of constant flux piercing the window plane the chief

SIGNIFICANT BRIGHTNESS RATIOS

Col. 3. Ratio of window wall to front chalkboard near window
Col. 4. Ratio of front wall above chalkboard to chalkboard
Col. 5. Ratio of ceiling near corner of front and window walls to chalkboard

Run	Conditions	Opening	Front Wall	Ceiling	Remarks
B2	Bare opening	68.	3.9	3.7	
B4	Horiz. Louvers, 0°	140.	6.2	9.1	Sky visible through louvers
B5	Horiz. Louvers, 40° tilt	28.	13.	21.	No sky visible
B7	Horiz. Louvers, 40° tilt	23.	14.	26.	High reflectance foreground
B8	Vert. Louvers, 40° tilt	8.3	6.8	5.7	No sky visible from rear of room
B10	Vert. Louvers, 40° tilt	9.3	6.7	8.2	High reflectance foreground
C27	Horiz. Louvers, 0°	87.	12.	34.	
C36	Horiz. Louvers, 40° tilt	46.	14.	37.	
C45	Vert. Louvers, 40° tilt	8.6	2.7	4.7	
D27	Horiz. Louvers, 0°	112.	13.	39.	
D36	Horiz. Louvers, 40° tilt	29.	10.	20.	
D45	Vert. Louvers, 40° tilt	11.5	4.7	7.	
E2	Horiz. Louvers, 0°	83.	10.8	28.	Sky visible through louvers
E3	Horiz. Louvers 40° tilt	61.	13.5	33.	No sky visible
E4	Vert. Louvers, 40° tilt	8.7	3.	4.8	No sky visible from rear of room
F2	Horiz. Louvers, 0°	105.	11.3	31.	Sky visible through louvers
F3	Horiz. Louvers, 40° tilt	37.	11.	21.	No sky visible
F4	Vert. Louvers, 40° tilt	11.	4.9	6.7	No sky visible from rear of room

effect of a high-reflectance foreground is to reduce the workplane footcandles near the window without changing appreciably the values remote from the window, thus improving the quality of lighting by reducing the deviation from the average. If comparisons are made on the basis of a constant sky brightness, then the chief effect of such foregrounds is to boost the illumination levels remote from the window, which is an obvious benefit.

Conclusions

The results of this investigation indicate that either horizontal or vertical louvers may be used to advantage in northern exposures. Horizontal louvers, tilted slightly, give a better footcandle distribution, but the control of brighness is in general better done by vertical louvers.

For rooms having other than northern exposure the vertical louvers did a better job of light control on all counts from the aspect of all room occupants who happen to be facing the front wall. The inherent lack of symmetry about an axis perpendicular to the window plane would seem, however, to rule out the use of vertical louvers for these exposures.

A better plan would utilize horizontal louvers with two angles of tilt. The louver blade adjacent to the window sill and, if necessary for proper cutoff, the one next above it should be set at a tilt of 20 degrees to 30 degrees. All blades above these should be set at 0-degree tilt. This would give adequate brightness control with a minimum amount of reduction in footcandles, regardless of the room exposure.

DISCUSSION

GEORGE V. PARMELEE*: The results of the illumination studies presented by Professor Bull are of particular interest to me. Since the summer of 1950 we at the Research Laboratory of the American Society of Heating and Ventilating Engineers, Cleveland, have been engaged in a study of the effect of louver or slat type sun shades on reducing sun heat through glass.

This project has had the supervisory guidance of the A.S.H.V.E. Technical Advisory Committee on Heat Flow Through Glass, most members of which are also members of the I.E.S. Daylighting Committee. The use of increasingly large glass areas in buildings presents a real problem to air conditioning engineers, who usually have to specify the use of some kind of shading device to bring cooling loads down to a reasonable level. The purpose of our present research is to provide more accurate and more extensive data on the reduction in heat gain possible by the use of the slat type shade.

The initial report on this problem was presented at the 1952 A.S.H.V.E. summer meeting in a paper entitled "The Shading of Sunlit Glass: An Analysis of the Effects of Uniformly Spaced Flat Opaque Slats" by G. V. Parmelee and W. W. Aubele. In this we gave an analytical means of predicting the fractions of the incident solar radiation absorbed, reflected and transmitted by slat type shades. These fractions are determined in terms of the geometrical proportions of the sun shade, the angle at which the slats are set, the position of the sun (or the energy distribution over the sky vault), and the reflectance of the slat surfaces. Both specular and diffuse reflecting surfaces were considered.

Although we have not yet made any attempt to determine the spatial distribution of the energy which passes through a given shade, it seems that the data could be of some value in predicting illumination effects where louver type shades are used. The data that Professor Bull has presented gives an opportunity to compare results with information in the form of total energy transmittances that can be developed from our analysis.

First, I would like to point out that the performance of slat type shades depends upon the dimensionless ratio, the slat width - slat spacing ratio. The louver arrangement of Professor Bull has a ratio of 5/4 or 1.25. This is the more or less standard ratio of venetian blinds, so that substantially the same results would have been achieved had standard blinds been used, if, of course, the reflectances of the slat surfaces were the same.

The results of two specific runs will be compared with what might be predicted from our mathematical analysis. Let us consider the series C tests. In runs Nos. 27 and 36 the slat angles were zero and 40 degrees respectively. To simplify the comparison the predicted results will be based upon a slat width - spacing ratio of 1.20 instead of 1.25 and the slat angle corresponding to run No. 36 will be taken as 45 degrees. The solar altitude will be taken as 50 degrees, the noon day value for March 21 at 40 degrees latitude.

If the slat surfaces are diffuse reflectors with a reflectance of 70 per cent, the horizontal slat setting of run 27 gives a total energy transmittance of 23.5 per cent while for the 45 degree setting approximating run 36, the value is 8.9 per cent. The ratio is 2.64. This compares favorably with 2.50, the ratio of the averages for the 48 stations. The presence of the glass introduces a nearly constant multiplying factor and therefore will be ignored.

Consider now the Series D tests in which the effect of the late afternoon sun on a south orientation was studied. At four o'clock the sun altitude is 22.5 degrees and the azimuth 70 degrees with the result that the profile or shadow line angle, of which transmittance is a function, is 50 degrees, exactly the same as at noon. Therefore, the ratio of total energy transmitted at the zero setting to that at the 45 degree setting is as before, namely 2.64. From Fig. 6 the ratio of the average of 48 readings in the No. 27 run to the average for the No. 36 run is about 38 to 15 or 2.54. However, the average illumination is about 25 per cent higher. If we consider 3 p.m., the profile angle is much lower, about 37 degrees and the ratio of total energy transmittance is 2.74. With both the zero and 45 degree louver setting, the energy transmitted is about 35 per cent greater than at 4 p.m. It would be interesting to know what sun angles were simulated. The 37-degree profile angle corresponds to about 33 degrees for both altitude and azimuth. If this were the case, it would seem that the use of total energy transmittances might be a useful tool in illumination problems.

It is worth noting that for a 40-degree altitude and zero azimuth of the sun, which corresponds to the last week in February, none of the direct rays of the sun will pass through louvers set at zero degrees. The illumination for

*Research Laboratory, American Society of Heating and Ventilating Engineers, Cleveland, Ohio.

the same footcandles on the window plane should be between the noon and 3 p.m. values for March 21. The ratio for louvers at zero to louvers at 45 degrees is about 2.60.

In closing I wish to emphasize that the problem of heat loads due to sun effects should not be ignored in attempting to raise illumination levels. The same statement applies to artificial lighting as well. It appears that substantial reduction in heat load can be accompanied by simultaneously improved quality of daylighting by the use of louver type shades. From the heat gain standpoint, the shades are most effective when used on the outside of windows. The whole problem certainly merits considerable further study.

W. J. ARNER*: Referring to Fig. 3 in the paper, it would appear from run B8 as compared to B9 that illuminations are better for the lower external ground reflectance than for the higher when readings are adjusted to 500 footcandles on the window plane. Since brightness ratios are not given for the higher ground reflectance, we can make no comparison here. In Fig. 4, however, for runs B5 compared to B7 higher illumination values were obtained for the higher external ground reflectance. In this case the lower brightness ratios would also favor the higher external ground reflectance at least when comparing the window wall to the chalkboard.

With reference to ground reflectances, the author cautions that careful interpretation is required. He points out that if comparisons are made on the basis of constant flux piercing the window pane (as has been done generally in the past), the chief effect of a high reflectance foreground is to reduce workplane footcandles near the window without changing appreciably the values remote from the window, thus improving the quality of lighting by reducing the deviation from average. At least, as applied to the reduction in quantity near the window, one can readily see that this yields a non factual observation due to a mathematical manipulation. Further, the author points out that if comparisons are made on the basis of a constant sky brightness, then the chief effect of such (high reflectance) foregrounds is to boost the illumination levels remote from the window, which is an obvious benefit. Certainly one can see that this latter procedure is the factual way to treat the data.

E. W. CONOVER**: My chief comment on this paper is directed at the practice of adjusting results to 500 footcandles on the window for all tests. As pointed out by Professor Bull and as shown by the curves, this method indicates less interior illumination for a high reflectance foreground than for one of low reflectance. This type of comparison is one of which several of us have been guilty in the past.

I would like to point out that as early as 1928 the Daylighting Committee of the I.C.I. set up as a standard for daylighting measurements a sky of uniform brightness giving a horizontal illumination of 5000 lux. It was recognized that the total interior illumination was a combination of that directly from the sky, that from exterior reflecting surfaces and that from interior reflectances.

In the Recommended Practice of Daylighting prepared by the I.E.S. Daylighting Committee prediction methods are based on an equivalent sky brightness of 1000 footlamberts which produces 1000 footcandles on the horizontal and 500 on vertical surfaces. It is pointed out that light colored exterior reflecting surfaces should be used wherever possible to increase the interior illumination.

*Libbey-Owens-Ford Glass Co., Toledo, Ohio.
**Detroit Steel Products Co., Detroit, Mich.

We believe, therefore, that tests and predictions should be all based on the same sky conditions rather than the same total flux on the window. This also applies to those tests with direct sun where the solar illumination would give about 3500 footcandles on the window, the sky 500 for a total of 4000 plus ground reflectances instead of reducing them to 500.

In the description of Series B Tests, Fig. 3 shows a test number 10 that is not described. Should this not be as given in the text for Run 9 and actually Run 9 have the glass and a standard foreground?

The louvers used were five inches wide and spaced four inches apart. Since the model is to ¼ scale these would represent louvers 20 inches wide in a full sized room at 16-inch intervals. Is it believed that the results would represent conditions when using ordinary venetian blinds?

Having had the opportunity of studying Professor Bull's complete report, I wish to compliment him on the tremendous amount of data that he compiled. It is believed that this contains valuable data that could be the basis for several papers and we suggest that he be asked to contribute at future conferences.

J. W. GRIFFITH*: The author is to be commended upon the obviously difficult task undertaken in this paper. It represents many man hours of work and helps to fill in the void of information about louver controls.

It is unfortunate that space requirements prohibited a discussion of the results for Series A. This series would more nearly represent what might be found in actual installations than does the uniform overcast Series B.

I would like to ask the author how the ground was illuminated in the artificial sky. If it was illuminated by a quarter sphere or its equivalent, it would be similar to a ground having a reflectance of 8 per cent and illuminated by a half sphere or the actual sky. If this is the case, the tests employing the 50 per cent reflectance would more nearly represent actual conditions or a ground having an average reflectance of 25 per cent.

The data in the figures is adjusted to 500 footcandles on the window plane. If a uniform overcast sky alone produces 500 footcandles on the window plane, then the same sky with an average ground reflectance of 50 per cent would produce 750 footcandles on the window plane. If these tests are compared on a constant window flux, the test giving the better results will actually be penalized since light entering a fenestration from below the horizon is reflected to the work plane from ceiling and upper walls.

It is, therefore, necessary to make all comparisons of tests taken with a ground reflectance whether in an artificial sky or under actual conditions on the basis of a constant sky brightness.

In Series C there is no mention as to how the ground was illuminated. If the ground was neglected on the sun tests then there can be no correlation between sun test and clear or overcast tests with ground. The light from the ground is much greater for sun conditions, because the ground is illuminated by the clear sky vault as well as the high intensity of the sun.

It is quite possible that the light from the ground may be greater than that from the clear sky for sun tests when the sun is not on the fenestration. It is regrettable that this condition has not been reported, but it is the hope of this writer that it is forthcoming.

*Research Associate, Southern Methodist University, Dallas, Texas.

I find it difficult to consider Series E and F feasible since the ground conditions are not even closely related as mentioned above, and since the clear sky pattern is not similar to the uniform overcast.

Not having the necessary information to change the figures and tables so that a comparison based upon a constant sky brightness can be made, I find it difficult to comment upon the results.

J. W. TUTTLE*: The subject of daylighting, particularly in the school field, is of considerable interest to the architect and school executive as well as to the illuminating engineer, and Professor Bull is to be congratulated for his exploratory work in this field.

A question has arisen in my mind regarding the paper. The Series A tests (a non-uniform sky brightness) would seem to be somewhat more typical of most actual sky conditions than the Series B tests in which the artificial sky was of approximate uniform brightness from zenith to horizon. The Series A tests, however, were not discussed in the paper. Will these data be made available later?

The Series C and D tests (which had to do with the measurement of simulated sunshine alone), show that the horizontal louvers tilted at 0 degrees are very good as far as footcandle distribution is concerned and evidently tolerable as far as brightness ratios are concerned for the specific conditions assumed. Both of these tests were run with simulated sunlight conditions as they would be for a room with southern exposure, 40-degree N latitude, in March. Series C was run with the sun in its noontime position, Series D with the sun in its "late afternoon" position which is assumed to be 3 or 4 p.m. since most schools are not used after that hour. For these two solar conditions as set up, direct sunlight will not enter the classroom and strike the children's eyes at any time during the school day. If, however, this same room were exposed to the solar conditions present during December instead of March, isn't it true that direct shafts of sunlight could enter the plane of the children's eyes during every hour of the school day? Also, wouldn't a western or eastern exposure equipped with 0-degree horizontal louvers allow some direct sunlight to enter the children's eyes during part of each school day throughout the whole school year? It would appear that by varying the solar conditions and room orientation the horizontal louvers with 0-degree tilt can be made to appear either good or bad. Direct rays of sunlight entering the schoolroom will obviously have a detrimental effect on brightness ratios as well as footcandle uniformity.

In the case of the fixed vertical louvers, if the tests for sunlight alone (Series C and D) were run with solar conditions as they exist in the morning when the sun could enter the classroom directly, instead of at noon and late afternoon, the brightness ratios would be considerably increased. Direct sunlight, while not in the eyes of the children, would be bothersome to the teacher. This type of louver might be used, however, in a study hall, where the supervising teacher might sit at the rear rather than the front.

WILLARD ALLPHIN**: It is rather disappointing that the author gave no consideration to vertical louvers normal to the glass, as introduced several years ago in the Bowditch Model Classroom.[1,2] Here 45-degree cut-off of sky brightness is achieved, and children facing either the front or the rear of the room receive equal protection.

When sunlight reaches the windows, white translucent shades are pulled down behind the louvers, so that the shades become secondary light sources.

1. "Brightness Control in a Model Classroom," Willard Allphin, ILLUMINATING ENGINEERING, Vol. XLI, No. 1 (January 1946).
2. "Daylighting a Classroom," I.E.S. Lighting Data Sheet No. 13-47.

H. S. BULL*: Mr. Parmelee, in the course of his valued discussion, raises the question as to the sun's position simulated in the Series D tests. The altitude was 50 degrees and the azimuth was about 40 degrees west of the south point. Convenience in changing the mounting of the projector spots was one factor affecting the selection of this position, since the chief purpose of this series was to enable the performance of louvers to be evaluated under more unfavorable operating conditions than the Series C provided.

I certainly agree with Mr. Arner and Mr. Conover that the important effects of high ground reflectances can be shown in a more understandable way by reference to a constant sky brightness. It is perhaps unfortunate that the limitations imposed on the test procedure by the space restrictions in the laboratory were such that reference to a constant flux at the window plane was required.

Mr. Conover is correct in noting an error in the preprint affecting the description of runs B9 and B10.

The distribution pattern brought about by the use of horizontal louvers can be expected to be similar to the results obtainable with venetian blinds. Louvers will be more efficient.

Mr. Griffith raises some questions regarding the method of producing ground illumination in the tests. In Series A and B the desired ground brightness was built up by the use of reflected light from the artificial sky plus a contribution from supplementary reflector floods where needed.

In Series C and D a group of runs for various louver arrangements was taken with the battery of projector spots pointed directly at the window opening. Then these runs were repeated with the spots moved away from the window and lowered so that they flooded the foreground with illumination equal to the value obtained at the window sill in the previous group of runs. Comparable data of the two groups of runs were then added station by station, to obtain a measure of total sunlight effect.

With regard to Mr. Tuttle's questions, I hope it will be possible to make more of the Series A data available at some future date. The use of horizontal louvers of 0-degree tilt does give good brightness control for all overcast sky conditions and clear sky not involving direct sunlight. There will be many situations, however, where this setting of the louvers will not produce the desired cutoff of direct sunlight. My recommendation for such cases would be to allow direct sunlight to enter the room through the upper louvers, but tilt the lower louvers enough to eliminate direct glare on desktops. The necessary angle of tilt would be governed by latitude and by the room orientation.

Mr. Allphin mentions the excellent results he has obtained with vertical louvers normal to the glass. One or two test runs using this arrangement were made in Series A. From these runs it was apparent that supplementary devices, such as translucent shades, would be required for certain sky brightness patterns. Since this investigation was directed primarily toward finding out what could be done in the way of brightness control with louvers alone, no further studies of this particular louver setting were made.

*General Electric Co., Cleveland, Ohio.
**Sylvania Electric Products Inc., Salem, Mass.

*Author.

A.I.A. File No. 31-f

Street Lighting

Installation A—Lighting a City Street

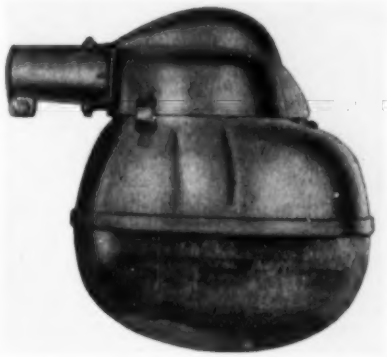
INSTALLATION ON MONUMENT AVE. (FROM MAIN ST. TO PATTERSON BLVD.) IN DAYTON, OHIO.

LIGHTING OBJECTIVE: To provide excellent visibility through a high level of illumination on a city business thoroughfare and main traffic artery.

GENERAL INFORMATION: The three 500-foot blocks of concrete roadway shown above are 45 feet wide. This street is one of the busiest in downtown Dayton.

INSTALLATION: General Electric Form 109 luminaires containing 20,000-lumen E-H1 mercury vapor lamps are mounted 5 feet out over the roadway and 28 feet above it; spacing is 80 feet opposite. Poles were manufactured by the Union Metal Manufacturing Company.

Maximum pavement illumination is 4.8 footcandles, minimum 2.9 and average 3.6.



Close-up of Form 109 luminaire

(over)

A.I.A. File No. 31-f

Installation B—Lighting a Bridge

INSTALLATION ON WEST FIRST ST. OVER MIAMI RIVER, DAYTON, OHIO.

LIGHTING OBJECTIVE: To provide good visibility on a bridge serving an urban main traffic artery.

GENERAL INFORMATION: This bridge is approximately 690 feet long and 80 feet wide. Pavement surface is black top and sidewalks are new cement.

INSTALLATION: General Electric Form 109 luminaires containing 15,000-lumen A-H1 mercury vapor lamps are mounted 2 feet out over the roadway and 28 feet above it. Spacing is 135 feet opposite. The poles were designed and furnished by the Elreco Company of Cincinnati, Ohio.

The resultan verage roadway illumination is 1.27 footcandles, maximum is 1.68, minimum 1.0.

Lighting designed by H. S. Nonneman of the Dayton Power and Light Company.

Lighting data submitted by H. S. Nonneman of the Dayton Power and Light Company, Dayton, Ohio, as an illustration of good lighting practice and to aid in the design of similar installations.

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The Importance of Ground Reflection In Daylighting

By J. W. GRIFFITH
O. F. WENZLER
E. W. CONOVER

DAYLIGHT reflected from the ground may contribute a great deal of illumination within a building. In fact, for vertical windows, this reflected daylight may be the major source of daylight. Consequently, the assumption that daylight arrives at a window directly from the sky only is basically in error, and architectural design for daylighting as well as daylighting prediction methods should take into account this reflected light arriving at the windows from below the horizontal.

The amount of reflected light depends on the light incident on the ground and the ground reflectance. The light incident on the ground can vary in intensity over a wide range depending on the sky brightness pattern and on the position of the sun. Its upper limiting value is approximately 10,000 footcandles.[1] Ground reflectance also varies over a rather wide range, as the reflectances of ground surfaces and ground cover commonly found in the vicinity of buildings may be in a range from 10 per cent to almost 100 per cent, with values in the range from 15 per cent to 50 per cent being most common. Typical ground reflectances are shown in Table I.

An indication of the contribution of light from ground reflections is shown by a theoretical computation for several typical conditions in Table II.

This table is computed on the basis of an overcast sky having an equivalent brightness of 1000 foot-lamberts, which has been employed for many years as the basis of daylight prediction methods.[4] This sky produces 1000 footcandles incident illumination on the horizontal outdoors and 500 footcandles incident illumination on the vertical window. The illumination incident on a vertical surface from the ground is computed on the basis of the incident horizontal illumination and the ground reflectances shown. It will be noted that the contribution from below the horizontal ranges from 9 per cent to 33 percent of the total incident light for the overcast sky and range of ground reflectances shown on this table.

TABLE I.—Typical Ground Reflectances.

	Per Cent		Per Cent
Grass fields, lawns	18-23*	Wild fields	26*
Dead grass	28-32	Concrete	55†
Meadows in foreground	14-18*	Macadam	18†
Meadows near horizon	35*	Gravel	15-35
Snow, fresh	100*		
Snow, old	59*		

*After Logan.[2]
†After Kimball.[3]

TABLE II.—Illumination Incident on Vertical Windows From Uniformly Overcast Sky Plus Ground Reflections.

Per Cent Ground Reflectance	10	20	30	40	50
Incident Illumination from Uniform Sky Only (Ft-c)	500	500	500	500	500
Incident Illumination from Ground Only (Ft-c)	50	100	150	200	250
Total Incident Illumination from Sky plus Ground (Ft-c)	550	600	650	700	750
Incident Illumination from Ground Only — % of Total	9.1	16.7	23.1	28.6	33.3

Non-uniform overcast skies usually are brighter at the zenith, thus producing more light incident on the horizontal for the same light incident on the vertical than does the uniform sky. The increase may be of the order of 25 per cent. This makes the percentage of light from the ground roughly 25 per cent greater for the non-uniform overcast sky than for the uniformly overcast sky used in the computations in Table II.

The contribution from the ground may be considerably higher yet for a clear sky with sunlit ground. In fact, for some conditions of sun and ground, there may be more light entering a window from below than from the sky.

This light reflected from the ground cannot be considered as, in effect, more light from the sky. The light from the ground is, instead, indirect light in a room. It reaches the work plane by interreflectance from the upper walls and ceilings. It may at times produce more light proportionately on the work surfaces farthest from the window than does direct sky light alone. It improves the uniformity of the illumination in the room and it improves the brightness ratios.

Just how effectively ground light is actually utilized in a room can best be shown by a study of ground light alone. Table III shows the maximum,

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AUTHORS: Research Associate, Southern Methodist University, Dallas, Texas; Manager, Sales Technical Service, Libbey-Owens-Ford Glass Company, Toledo, Ohio; and Research Engineer, Detroit Steel Products Company, Detroit, Michigan, respectively.

TABLE III.—Interior Illumination from Ground Light Only.

Vertical Illumination	100 Footcandles			150 Footcandles			250 Footcandles		
	Work Plane Illumination								
Reflection Factors*	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.
30-50-85	16.4	9.6	4.4	24.6	14.4	6.6	41	24	11
30-70-85	17.4	10.8	5.8	26.1	16.2	8.7	43.5	27	14.5
30-50-70	16.2	9.0	4.2	24.3	13.5	6.3	40.5	22.5	10.5
30-70-70	18.0	10.4	5.6	27.0	15.6	8.4	45	26	14

*Of floor, walls, and ceiling, in that order.

average and minimum readings of illumination on the work plane of a typical room with light coming from the ground only. These readings were taken at Southern Methodist University in a one-fourth scale model representing a 30 x 30 x 12-foot room. The sky was black for this series of tests and all of the incident light was from the ground. The fenestration was clear glass extending from wall to wall and from a 36-inch sill to the ceiling, and corrections have been introduced to allow for a 20 per cent reduction representing the effect of the mullions and muntin bars typical of metal window construction. Data are shown for 30 per cent reflectance on the floors, 50 and 70 per cent reflectance on the walls, 70 per cent and 85 per cent reflectance on the ceilings. Readings were taken at stations representing five-foot intervals throughout the room at 30 inches from the floor.

Values computed from actual test results are shown for 100, 150, and 250 footcandles incident on the window from the ground alone. These represent the ground light which would be received for typical ground reflectances of 20 per cent, 30 per cent, and 50 per cent, respectively, representative of grass, gravel and concrete, if these grounds were illuminated by the 1000-footlambert uniformly overcast sky. They also represent the light which would be received for average ground brightnesses of 200, 300, and 500 footlamberts, respectively. Light received from the ground for other conditions would be proportional to the average ground brightness.

From the data shown in Tables II and III it appears advisable for comparison of daylighting installations or for daylighting prediction to evaluate the reflected light from below the horizon and add it to that received directly from the sky. It has been common practice to use a reading of the total light incident on a vertical fenestration as a basis for comparison of daylighting tests results. Such a procedure, however, does more than just neglect the added light available from the ground. It actually penalizes the installations with higher ground reflections for their more effective utilization of light.

For example, consider two identical rooms, each lighted by a uniformly overcast sky of 1000 footlamberts brightness, one having zero ground reflectance outside the window, the other having 30 per cent ground reflectance. The room with 30 per cent ground reflectance would obviously have more light on the work plane. Each window would receive 500 footcandles directly from the sky, but the one with 30 per cent ground reflectance would receive an additional 150 footcandles by reflection from the ground for a total of 650 footcandles incident on the window. Since this light from the ground must be reflected from the ceiling or upper walls before being distributed to the work plane, it produces less light quantitatively on the work plane than does an equal amount of sky light. Consequently, if the readings for the latter room were adjusted to a base of 500 footcandles incident instead of 650, the adjusted illumination values for this room would be lower than those for the room with zero ground reflectance.

In making this type of comparison, therefore, the utilization of light for the room with ground reflections has been penalized by considering only a fraction of its interior illumination, while considering all of the illumination for the room having no light from the ground. A fairer comparison could be made by using an overcast sky having an equivalent brightness of 1000 footlamberts as a basis rather than adjusting to 500 footcandles incident on the window.

The utilization of ground light is not a new phenomenon. It has been used for years, but many installations have been penalized by lack of its consideration. Horizontal louvers such as Venetian blinds, for example, can be adjusted to shield the eye from high sky brightness when objectionable, and still allow reflected light from below to pass through for indirect daylighting. Strategic location of concrete parking areas, sidewalks, and light colored playground areas can be incorporated effectively into many designs. Roofs under clerestory and similar windows can be treated as reflectors to increase the amount of light reflected into the windows from below.

Light from below the horizon is bonus light. It is a dividend from something whose only cost is good design practice.

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DISCUSSION

R. A. BOYD*: The authors of this paper are to be congratulated on having brought to our attention a factor in daylighting that is especially important today when we are concerned about greater quality and improved methods of daylighting.

For some time the Daylighting Laboratory at the University of Michigan has been collecting exterior illumination data on both clear and cloudy days. These data, in general, substantiate the statements made by the authors regarding the importance of ground reflections. Also, we have collected daylighting data for various classroom arrangements with different amounts of ground reflected light. From these data we have been able to determine the effectiveness of direct light from the sky and of ground reflected light. For a 24 x 32 x 12 foot classroom having an unshaded clear flat glass fenestration, and ceiling, walls and floor reflectances of 85, 60 and 30 per cent, respectively, the illumination of a work plane, on the centerline of the room and 21 feet from the fenestration wall, was 0.082 footcandle per footcandle of exterior illumination due to direct light from a clear sky and 0.060 footcandle per footcandle of ground reflected light. These agree reasonably well with the average value of .073 for both components given in the preceding paper.

When clear flat glass is equipped with horizontal louvers set at an upward tilt of 45 degrees the effectiveness of ground-reflected light is considerably greater than that for direct light from the sky. Our data indicates that one obtains, in the case referred to above, about 0.025 footcandle per footcandle of ground reflected light and about 0.010 footcandle per footcandle of direct light from the clear sky.

This consideration of ground reflections serves to indicate that they should be taken into account in any prediction method and that in the collection of field data the exterior illumination of the fenestration should be measured in two parts.

The authors mentioned that ground reflections have an influence on the quality of the daylighting and it is hoped that they will present further information along these lines.

H. S. BULL**: I have read this paper with a great deal of interest. The importance of ground reflection is very convincingly presented and all of us need to be reminded frequently of the benefits in daylighting to be derived therefrom.

There are obvious difficulties in attempting to predict ground contributions quantitatively because of the non-uniformity of reflectance of the contributing area and because the vital portion of this area may be so located as to produce a very non-uniform flux distribution at the window plane.

Both the calculated and experimental data forming the basis of this paper were obtained without light control devices in the window. Without disparaging their importance in any way it should be mentioned that there are very few situations today where we would wish to design for daylighting without the help of louvers or venetian blinds in bringing about satisfactory brightness ratios. Control devices of this sort, as usually adjusted, merely block out portions of the sky flux with relatively little diminution of the ground flux. If a high reflectance ground cover is available, so much the better.

BERNARD F. GREENE*: This paper very correctly points out the importance of the light from below the horizontal in daylighting. It was of interest to note the increased illumination within the room due to the light reflected from the ground. We would like to see how the brightness ratios throughout the room are varied by the contribution of the reflected component of daylight.

A disadvantage of the light from below the horizontal is the possible high brightness of ground sources. With the direct sun shining upon an outside concrete apron it is possible to obtain reflected brightness values of upwards of 4000 footlamberts. With this high brightness below the horizontal, it is difficult to provide adequate means of shielding.

R. W. MCKINLEY**: Thank you gentlemen for directing our attention to one of the "under privileged" components of the daylighting art. Possibly, I can be of some assistance by extending your analysis from the theoretical computations and model studies which you have conducted to a brief comment regarding our own experience with actual field measurements.

Perhaps it is almost sufficient to say that ground reflections seem to contribute almost as much in practice as the theoretical analysis and model studies would indicate. From what we have observed, with unobstructed fenestration walls there should be good agreement between actual field measurements and the laboratory work reported here.

Our own interest in this subject is quite evident when one examines the type of exterior "control" photocell which we have used as a standard means of determining the illumination of the fenestration in our job survey work. Our control cell accepts light incident from all angles including the ground. Full credit is given in all our reports for all the light incident on the fenestration including that from the ground and our analysis of this ground component indicates that with functional fenestration systems such as those represented by our light-directing and light-diffusing glass blocks, excellent use is made of the ground component. For example, we find that the light utilization of a functional panel is nearly uniform over a wide range of exterior distribution conditions.

Actual measurements indicate that the utilization of ground shine is about 90 per cent as effective as the utilization of sky sunshine.

Lest I be catalogued amongst the "me toosists" I would like to use the authors' own figures to point out one of the problems that light reflected from the ground creates which should also be kept in mind when planning fenestration systems with ground reflection as an important factor.

Turning to Table III I imagine that the right hand column of footcandle values averaging about 12 footcandles represents the illumination under the model test conditions on a work plane perhaps 25 feet from the fenestration wall. I believe that all of you will agree that the brightness of a book placed on that work plane would be approximately 10 footlamberts. Now it is stated in the paper that the average ground brightness related to these figures was 500 footlamberts. Though it is not stated just how large an area of light concrete outside the room would have to be to produce this result, I think the authors would agree that it would have to be somewhat larger than a postage stamp and that it would probably occupy a fairly large area in the field of

*University of Michigan, Ann Arbor, Mich.
**University of Michigan, Ann Arbor, Mich.

*Consulting Engineer, New York, N. Y.
**Pittsburgh Corning Corp., Pittsburgh, Pa.

view of a person looking out the window. According to my calculations, the brightness ratio between the task and the 500-footlambert ground is something of the order of 50 to 1. Seems to me this is getting out of the comfort range.

Continuing along this line of analysis, I would add a strong word of caution on the basis of extensive experience with the ribbon windows so frequently used in connection with light directing block panels. Because of the problems of purchasing, maintaining, and adjusting interior shading devices, many architects have used projecting louvers or eyebrows above these ribbon windows in order to provide brightness control and eliminate these other headaches. On a due South elevation, I think it is quite a practical means of providing the desired control though it must be recognized that there will be times when there will be glare discomfort particularly on the part of the teacher in certain areas. Perhaps I can illustrate the extreme case by considering such an arrangement in an area frequently experiencing long months of snow cover. Here whether the louver is well dsigned for eliminating direct sunlight or not, the reflected light off of the bright snow will cause glare discomfort in people standing in the room. I would say that under circumstances where sand or concrete takes the place of snow the difficulty would be about half as bad because their reflectance is half as much according to the authors' figures.

Again thanks to the authors for reminding us of a worthwhile source of daylight but please keep in mind that the same problems of brightness control exist whenever a source delivers a useful quantity of working illumination.

J. W. Griffith, O. F. Wenzler, E. W. Conover*: We agree with Professor Bull's statement that there are obvious difficulties in attempting to predict ground contribution. However, we feel that it is a problem that must be answered in evaluations and predictions before they can be of any great value to the Illuminating Engineer, or the Architect.

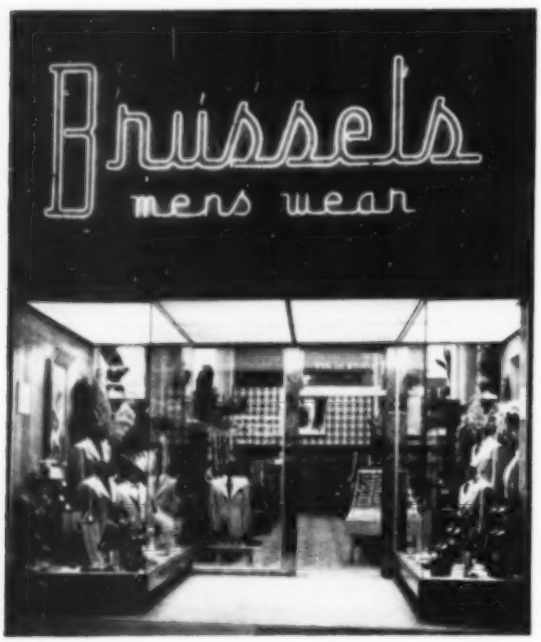
We also realize the necessity of similar studies involving control devices and we are in the process of doing just that. The effect of ground reflections on brightness ratio is also an important contribution but it too is down the road.

Mr. McKinley states that they measure the incident light from the ground along with that from the sky for their surveys. We see little value in that measurement by itself if the tests are to be used for evaluation or comparative purposes. Most surveys are made for such purposes and it would be basically in error to compare two installations that have the same incident illumination but have different sources. The uniformity of light utilization over a wide range of exterior distribution referred to is most likely due to different sky brightness conditions. We believe that considerable difference in light utilization will be found if the surveys with wide range of exterior distribution conditions are compared on a similar source basis rather than that of a constant incident flux.

Mr. McKinley points out that a brightness ratio of 50 to 1 exists between the ground and task on a desk 25 feet from the window, based on Table III. Mathematically this is true, but unless the window wall extends below the average sill the two areas will not be in the same field of view. Even for lower sills the ground would be a small area out at the edge of the field of view for a head position using the work plane as the task, thus having little effect on seeing the task.

Shielding high ground brightness from the teacher is very effectively done by venetian blinds. If the ground brightness is such as to become disturbing the teacher simply adjusts the blind and moves away, or even looks away, from the disturbing area.

*Authors.



Men's Wear Store Front Uses Louverall Ceiling

An eggcrate louverall ceiling with 1½ x 1½ x 1-inch cells is used over the entrance lobby and display windows of the Brussels Men's Wear store in San Diego, Calif. In the window area the 2-lamp units, containing 8-foot lamps, are mounted side by side as closely together as possible and produce an illumination of 200 footcandles. Over the lobby the same units are spaced on 12-inch centers, providing 90 footcandles.

In the store interior two continuous rows of egg-crate louvered luminaires containing 8-ft T-8 slimline lamps are mounted on the 16-ft ceiling.

Photo and data submitted by W. A. Alden, Westinghouse Electric Corp., Los Angeles, Calif.

A Lumen Method of Daylighting Design

By R. L. BIESELE, JR.
W. J. ARNER
E. W. CONOVER

THIS PAPER presents the basis of a new method of daylighting design and daylight prediction for interiors. It has been prompted by the fact that the existing methods of daylight prediction, such as the rectangular surface source methods of Higbie,[1,2] and Moon and Spencer,[3,4] the daylight factor or sky factor methods of Waldram[5] and others, and the Fenestra method of Randall and Martin,[6] have been limited in their application by the assumptions made in their development. In general, these methods have been applicable to large spaces such as industrial plants, in which interior reflections and ground reflections have had little significance.

During the past two years, therefore, the major objective of the Daylight Study Project at Southern Methodist University, sponsored by the Detroit Steel Products Company and the Libbey-Owens-Ford Glass Company, has been to develop a prediction method which would be applicable to a different range of conditions, to smaller spaces such as classrooms, offices, hospital rooms, small industrial spaces, and the like, in which interior reflections and ground reflections do have significance.

The method outlined in this discussion is based on the premise that it is unnecessary to know the exact illumination at every point in the room, if a determination can be made of the average illumination, the minimum illumination, and the maximum illumination, since these three values would be considered sufficient by the practicing architect and illuminating engineer.

Even so, the problem has been quite complex, because of the large number of independent variables which affect the amount and distribution of daylight reaching the work surfaces of a daylighted room. The variables can be divided into several categories as follows:

A. Variables affecting the amount of light reaching the windows from above the horizontal.

1. The brightness and brightness pattern of the clear or overcast sky. (A partially cloudy sky is even more variable.)
2. The angular position of the sun with respect to the window, and the sun intensity.

B. Variables affecting the amount of light reaching the windows from below the horizontal.

1. The horizontal illumination of the ground (determined by the brightness and brightness pattern of the sky, plus the angular position of the sun with respect to the ground and the intensity of the sun.)
2. The reflection factor of the ground or ground cover.

C. Variables affecting the amount of light leaving the inner surface of the window or fenestration for a given amount of light incident on the outside of the window.

1. The window area.
2. The ratio of actual transmitting area to nominal fenestration area.
3. The actual transmission factor of the clean transmitting media for the incident light conditions.
4. The effect of dirt collection on the transmission factor of the transmitting medium, in service.

D. Variables affecting the utilization and distribution of light on the work plane after leaving the inner face of the window.

1. The distribution pattern of the light leaving the window.
2. Geometric factors as follows:
   a. The length and height of the window.
   b. The height of the window above the work plane.
   c. The height of the ceiling.
   d. The ratio of ceiling or window height to room width and room length.
3. Reflection characteristics of the ceiling, walls and floor of the room.

The list is impressive, and made a point-by-point method appear impractical. Consequently, it was deemed advisable to investigate a possible lumen method of daylighting design. This was to be patterned after the basic Harrison-Anderson lumen method for interior lighting design,[7,8] since it appeared to afford the best possibility of allowing for all the variables. In particular, it was to employ

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AUTHORS: Research Professor of Engineering, Southern Methodist University, Dallas, Texas; Research Department, Libbey-Owens-Ford Glass Company, Toledo, Ohio; Research Department, Detroit Steel Products Company, Detroit, Michigan, respectively.

a similar computation technique, since most illuminating engineers and architects are familiar with the Harrison-Anderson method. This attack has proved quite fruitful, even though the number of variables to be encompassed has been greater for the daylighting problem than for artificial lighting.

Basic Considerations

The Harrison-Anderson method is essentially a technique for rapid determination of the average horizontal illumination to be expected on the work plane in the interior being studied. Its basic feature is the concept of a "Coefficient of Utilization," which can be expressed as follows:

$$\text{Coefficient of Utilization} = \frac{\text{lumens reaching the work plane}}{\text{generated lamp lumens}}$$

In the case of daylight, a similar coefficient of utilization can be postulated. To avoid confusion with the Harrison-Anderson term, however, it will be referred to as the "Average Illumination Coefficient," which can be expressed as follows:

$$\text{Average Illumination Coefficient} = \frac{\text{lumens reaching the work plane}}{\text{lumens incident on the nominal window area}} = K_{avg}$$

This average illumination coefficient depends on similar factors to those which determine Harrison's coefficient of utilization, such as the amount and distribution of light flux leaving the windows, the room geometry, and the room finishes. There are, however, certain essential differences.

First, the amount of daylight flux varies depending on a number of external factors which have been listed previously, whereas the generated lamp lumens of a given electric lighting installation can be considered constant.

Second, whereas the Harrison-Anderson method assumes and even restricts the placement of luminaires in a symmetrical arrangement such that the illumination at any point will not differ greatly from the average illumination, the very asymmetry of the more common daylighting designs precludes this possibility. The daylighting designer must be concerned therefore with the minimum illumination which will be produced on the work plane, and will at times be concerned with the maximum as well. Consequently, two additional coefficients are postulated, which are defined as follows:

$$\text{Minimum Illumination Coefficient} = \frac{\text{Minimum work plane illumination} \times \text{work plane area}}{\text{Lumens incident on the nominal window area}} = K_{min}$$

$$\text{Maximum Illumination Coefficient} = \frac{\text{Maximum work plane illumination} \times \text{work plane area}}{\text{lumens incident on the nominal window area}} = K_{max}$$

As a result, when the designer is concerned with the minimum and maximum illumination, in addition to the average, it is necessary for him to determine the additional coefficients, and to repeat his calculations to establish the minimum and maximum illumination values.

A second basic feature of the Harrison-Anderson method is the use of a "Room Index" to account for the effect of room geometry. It has proved advantageous in the development of this daylight computation method to adopt a similar index to account for room geometry. Again, to avoid confusion with the Harrison-Anderson term, this index will be referred to as the "Window Index," with the symbol "W.I."

Experimental Technique

The method presented here is an empirical one, based on an extensive series of tests. The tests were conducted in a one-quarter size model, Fig. 1, lighted by what is believed to be the largest artificial sky in active use at present for daylighting experimentation. The model and artificial sky were employed for several reasons, most important of which were that any desired sky brightness pattern

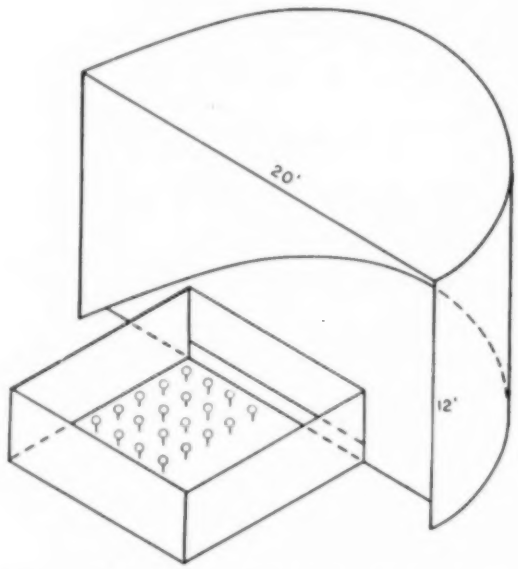

Figure 1. Sketch showing artificial sky, right, with one-quarter scale model, left, with photocells in position for test. Sky illuminated by light sources above and at sides of model.

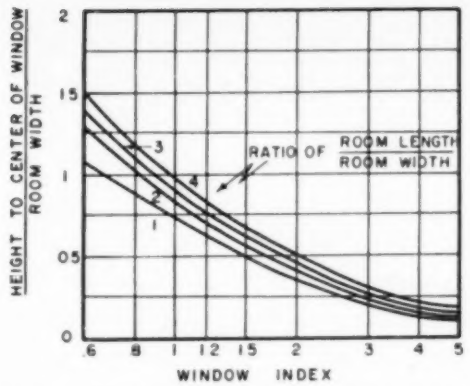

Figure 2. Curves for determination of Window Index for light from sky alone.

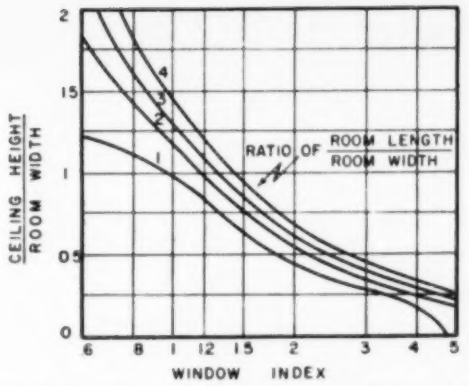

Figure 3. Curves for determination of Window Index for light from ground alone.

could be held constant, and reproduced consistently for successive tests.

The test program has included a study of the following variables:

1. Room sizes from 10 feet by 10 feet to 40 feet by 40 feet, including square and rectangular rooms, with ceiling heights from 8 feet to 14 feet.
2. Reflection factors of 85 per cent, 70 per cent, and 4 per cent on ceiling; 70 per cent, 50 per cent, 30 per cent and 4 per cent on walls; and 30 per cent and 4 per cent on floor.
3. Sky brightness patterns representing clear, overcast, and uniformly bright skies, all without ground reflections.
4. Independent studies of light from below horizontal representing ground reflections, with no sky light.

Tests covered by the data of this paper include only those applying to clear glass windows set vertically in one wall, extending without major breaks the full length of the wall, and extending from a normal sill of 30 to 42 inches to a window head not more than 12 inches below the ceiling.

Instrumentation has proved to be a major problem, as in all daylighting research. Color and cosine corrected photocells have been employed for the measurements. The cells have been mounted on clear plastic stands to a height representing a conventional 30-inch work surface. Stands were arranged to permit precise levelling with a bubble level each time the cell was moved. The artificial sky and model were located in an air-conditioned space to eliminate any drift due to temperature and humidity variations. Cells and galvanometer have been calibrated on the optical bench against photometric standards each day of testing.

Each cell was used consistently in the same position during the test program. Test stations were at five-foot intervals, in terms of full scale, in each direction, beginning five feet in from the window and from the end walls. Cell readings were taken with a high-sensitivity, low-resistance laboratory galvanometer to assure linearity, and considerable precautions were taken to eliminate thermal and other stray measurement circuit effects. Cells were connected to the galvanometer for reading by means of a switching arrangment which connected a resistance equal to that of the galvanometer across the photocell terminals at all times except when actually taking a reading. In order to eliminate fatigue effects, the sky was left lighted at all times, so that cells were continually illuminated at levels in the range of those which the cells were reading during the actual tests.

The lighting system for the sky was arranged to permit switching readily from one sky pattern to another. This lighting system was supplied from carefully regulated constant-voltage supplies. Sky patterns for clear and overcast skies approximate closely those shown on the right-hand portions of Figures C-4 and C-7, page 25, of the Recommended Practice of Daylighting.[9] The ground brightness pattern was uniform, as was the uniform sky pattern.

Daylighting Performance Data

The data obtained were voluminous. Approximately four hundred tests have been included in the data evaluated for this paper, and a nearly equal number of preliminary tests were run while perfecting techniques and in studying the effects of individual parameters.

The six curves, Figs. 2 through 7, present the essence of the data. Figs. 2 and 3 give Window Index values for light from sky alone and light

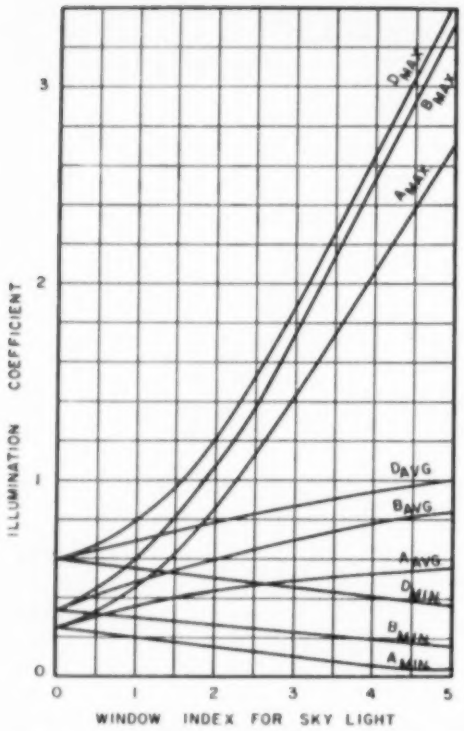

Figure 4. Illumination Coefficient - Window Index curves for light from clear sky only. Reflection factors: A—Ceiling 4 per cent, walls 4 per cent, floor 4 per cent. B—Ceiling 85 per cent, walls 30 per cent, floor 30 per cent. D—Ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

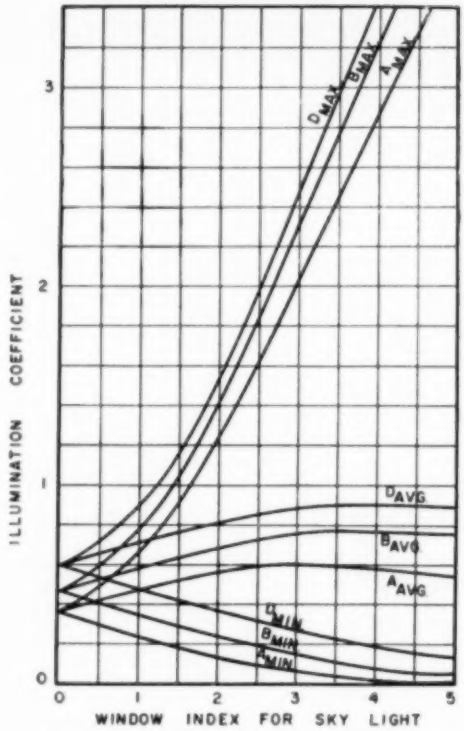

Figure 5. Illumination Coefficient - Window Index curves for light from overcast sky only. Reflection factors: A—Ceiling 4 per cent, walls 4 per cent, floor 4 per cent. B—Ceiling 85 per cent, walls 30 per cent, floor 30 per cent. D—Ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

from ground alone, respectively. They are quite similar to the corresponding "Room Index" curves for the Harrison-Anderson technique, as published in the Westinghouse Lighting Handbook, 1943.[10] The curves as shown give a good empirical fit for the data analyzed in detail at the time of writing. Further analysis may indicate the desirability of some modifications, however, which would in turn affect the curves of Figs. 4 through 7.

The curves of Figs. 4 through 7 give the Average, Minimum, and Maximum Illumination Coefficients for Clear, Overcast, and Uniform Sky Brightness Patterns, and for Ground Brightness, respectively. The first three are for light entering the room in a predominantly downward direction and represent what can be considered as very broad spread direct lighting distribution. The fourth is for light entering the room in an upward direction, and represents an indirect lighting distribution.

Although the curves were obtained for clear glass for various incident lighting conditions, it is anticipated that the distribution of light inward from the various commonly used glazing and control media, such as clear and patterned glass, diffusing shades, or draperies, louvers, blinds, or refracting media, will be found to be of such a nature that each can be closely approximated by some combination of these basic distributions. The curves as shown reflect the directional effect of two air to glass faces, but the coefficients obtained from them must be adjusted in use for the transmission factor of the glazing and control media for the incident light condition, as well as for the obstruction due to window elements such as mullions, muntin bars, or mortar joints, which reduce the net transmitting area below that of the gross area of the masonry opening.

The curves as given here do not include all combinations of reflection factors which were tested. This omission has been intentional, as a greater number of curves per figure would have introduced confusion, and space limitations have precluded additional figures at this time. It is believed, however, that the curves presented will by interpolation permit work of sufficient accuracy for most practical problems.

In addition, no data have been presented here for conditions of sun on the windows. The data are

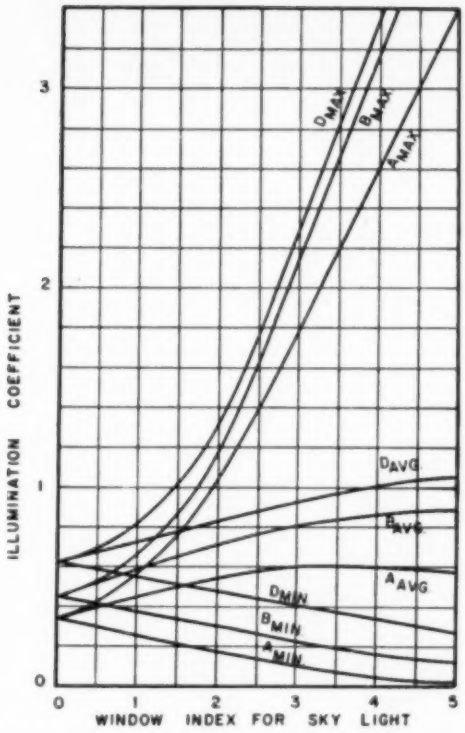

Figure 6. Illumination Coefficient - Window Index curves for light from uniform brightness sky only. Reflection factors: A— Ceiling 4 per cent, walls 4 per cent, floor 4 per cent. B—Ceiling 85 per cent, walls 30 per cent, floor 30 per cent. D—Ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

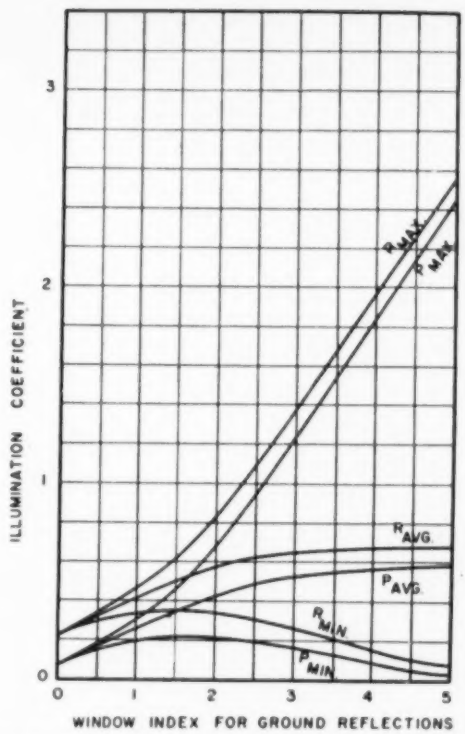

Figure 7. Illumination Coefficient - Window Index curves for light from ground only. Reflection factors: P—Ceiling 85 per cent, walls 30 per cent, floor 30 per cent. R—Ceiling 85 per cent, walls 70 per cent, floor 30 per cent.

confined for the present to windows glazed with clear flat glass, with light from sky and ground.

Example

Compute the average, minimum, and maximum illumination produced in a 30x24x12-foot classroom, with reflection factors of 85 per cent ceiling, 60 per cent walls, and 30 per cent floor, with windows extending the full length of one 30-foot wall, and from a 42-inch sill to the ceiling, with clear flat glass, and with no controls in the windows. Assume a clear sky having a brightness pattern as shown on the right side of Figure C-4, page 25, "Recommended Practice of Daylighting," which produces 287 lumens per square foot incident on the vertical windows. Assume a sun position and ground reflectance such that light from ground reflections produces 213 lumens per square foot incident on the vertical windows, for a total of 500 footcandles total incident light.

Step 1. Determine the Window Index for Sky Light from Figure 2.

(a) Height to Center of Window = $H_{cw} = 7.75$ feet

(b) Room Width = $W = 24$ feet

(c) Room Length = $L = 30$ feet

(d) $H_{cw}/W = 7.75/24 = .323$

(e) $L/W = 30/24 = 1.25$

(f) Window Index for Sky Light (from curve) = W.I.$_s$ = 2.20

Step 2. Determine the Illumination Coefficients for Clear Sky Light from Figure 4.

(a) Aver. Illumination Coefficient = $K_{savg} = 0.76$

(b) Min. Illumination Coefficient = $K_{smin} = 0.45$

(c) Max. Illumination Coefficient = $K_{smax} = 1.29$

Step 3. Determine the Average, Minimum, and Maximum Work Plane Illumination from the Clear Sky Light Only.

(a) $$E_{savg} = \frac{E_{is} \times A_w \times K_{savg} \times T_g \times T_w \times M.F.}{A_f}$$

where

E_{savg} = Average Work Plane Illumination from Sky Light, footcandles

E_{is} = Illumination Incident on Vertical Windows from Sky Alone, footcandles

A_w = Area of masonry opening for window, square feet

K_{savg} = Average Illumination Coefficient for Sky Light

T_g = Transmittance of glazing medium for diffuse incident light (0.8 for clear flat glass)

T_w = Ratio of clear window opening to masonry opening (0.8 for typical metal window construction)

$M.F.$ = Maintenance Factor (Assumed 1.0 — representing initial conditions — for this example)

A_f = Area of floor, or work plane, square feet

$$E_{savg} = \frac{287 \times 8.5 \times 30 \times .76 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 49.5 \text{ Ft-c}$$

Similarly,

(b) $$E_{smin} = \frac{287 \times 8.5 \times 30 \times .45 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 29.3 \text{ Ft-c}$$

(c) $$E_{smax} = \frac{287 \times 8.5 \times 30 \times 1.3 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 84.7 \text{ Ft-c}$$

Step 4. Determine the Window Index for Ground Light from Figure 3.

(a) Ceiling Height = H_c = 12 feet
(b) $H_c/W = 12/24 = 0.5$
(c) $L/W = 1.25$
(d) Window Index for Ground Light (from Curve) = 1.9

Step 5. Determine the Illumination Coefficients for Ground Light from Figure 7.

(a) Aver. Illumination Coefficient = $K_{gavg} = 0.52$
(b) Min. Illumination Coefficient = $K_{gmin} = 0.32$
(c) Max. Illumination Coefficient = $K_{gmax} = 0.75$

Step 6. Determine the Average, Minimum, and Maximum work plane illumination from Ground Light only.

(a) $$E_{gavg} = \frac{E_{ig} \times A_w \times K_{gavg} \times T_g \times T_w \times M.F.}{A_f}$$

where

E_{gavg} = Average work plane illumination from ground light, footcandles

E_{ig} = Illumination incident on vertical windows from ground alone, footcandles

K_{gavg} = Average illumination coefficient for ground light

$$E_{gavg} = \frac{213 \times 8.5 \times 30 \times .52 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 25.1 \text{ Ft-c}$$

(b) $$E_{gmin} = \frac{213 \times 8.5 \times 30 \times .32 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 15.5 \text{ Ft-c}$$

(c) $$E_{gmax} = \frac{213 \times 8.5 \times 30 \times .75 \times .8 \times .8 \times 1.0}{30 \times 24}$$

$$= 36.2 \text{ Ft-c}$$

Step 7. Determine the Average, Minimum, and Maximum work plane Illumination from Sky Light and Ground Light

(a) $E_{avg} = E_{savg} + E_{gavg} = 49.5 + 25.1 = 74.6$ Ft-c
(b) $E_{min} = E_{smin} + E_{gmin} = 29.3 + 15.5 = 44.8$ Ft-c
(c) $E_{max} = E_{smax} + E_{smin} = 84.7 + 36.2 = 120.9$ Ft-c

The daylighting prediction method presented in this paper has a number of features to commend it, as follows:

1. It is relatively simple. It employs a computation technique with which many architects and all illuminating engineers are already familiar, and which many of them use regularly in artificial lighting design.

2. It may prove possible with further study to develop tables of illumination coefficients for almost any desired types of fenestration and controls, for any desired sky and ground brightness patterns, as well as for direct sun conditions. Such tables would initially involve fairly extensive experiment for their empirical development. With experience, it may be possible to devise methods of developing the tables from the distribution curves of light leaving the inner surfaces of fenestration and controls. Such tables would simplify the method further.

3. The method, by interpolation and extrapolation, is applicable to an almost infinite number of room sizes and shapes, and window arrangements, and hence should be widely useful in daylighting design.

4. The method can assume any desired initial sky or sun conditions, thus permitting computations for any time of day or year, in any locality, for any orientation, and for any special or unusual conditions under consideration.

5. The method takes into account the exact behavior of interreflections and ground reflections, in spaces such as classrooms, offices, hospitals, small industrial spaces, and similar areas where such reflected light is important.

In short, it is a general method of daylighting design and prediction, which should prove widely useful in the architectural and engineering design of daylighted buildings.

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9. "Recommended Practice of Daylighting," Illuminating Engineering Society, New York, N. Y. (May 1950).

10. "Lighting Handbook," Westinghouse Electric & Manufacturing Company, Lamp Division, Bloomfield, New Jersey, p. 62-64 (1943).

DISCUSSION

RUSSELL C. PUTNAM*: For the illuminating engineers who deal almost entirely with electric lighting, the complexity and uncertainty of daylighting computations seem rather baffling. A paper such as this is welcomed as a much needed step toward a simpler approach that might parallel electric lighting computations. It should be read with great interest.

Unfortunately, curves for Fig. 4 and Fig. 5 were interchanged in the paper as preprinted, which made it impossible to check the example given to illustrate the method. This has been corrected in the paper as printed here, but as many engineers prefer to use the convenient preprint form, this error should be noted and the preprint changed.

The advantages of this lumen method of daylighting design as summed up at the end of the paper evidently include future work that may be planned, or information that may be published in later papers. This paper is concerned only with conditions of clear sky, overcast sky or sky of uniform brightness, and gives no data involving the addition of a component from the sun.

As a first paper the possibilities of the lumen method of daylighting design are indicated, and this discussor will look forward with interest to future developments.

DOMINA EBERLE SPENCER**: In many ways this is a good paper. Certainly, daylight calculations that include interflections are needed. The principal fault of the paper is that it is pitched at the level of the Harrison-Anderson lumen method of 1916. In the last 35 years there has been considerable development in the treatment of interflections of light. We have progressed from the expensive, laborious, empirical determination of coefficients of utilization to the comparatively simple theoretical treatment of the interflection method which gives not only quantity of light but also enables us to predict the distribution of light on walls, ceilings, and floors. If Biesele, Arner, and Conover had been working a quarter of a century earlier their strictly empirical approach would be justified. Today we have adequate theoretical means to obtain much more general results than are likely to ever be worked out on an empirical basis.

The interflection method has been applied with considerable success to artificial lighting[1] and also to some special cases in daylighting.[2] What is needed, is to complete the application of the interflection method to daylighting. For this application the only experimental data needed are a specification of the amount of light incident on wall, ceiling, and floor (without interflections) for typical types of fenestration lighted by overcast and clear skies. Then, by the methods[2] developed already, or a slight generalization thereof, both quantity and quality can be handled in a form similar to the lumen method for all types of daylighting.

There is one detail of the Biesele, Arner, Conover paper that I should especially like to question. Is there any justification for introducing still another room index: the empirically defined window index "W. I."? The specification of room shape, k_r, employed in the interflection method under the name "domance" has already been shown to have both a theoretical and an experimental basis in artificial lighting. And the integral equation formulation of the daylighting problem for very long rooms[2] is also expressed in terms of k_r. Although we do not yet have a proof that the general daylighting problem for rooms of finite length can be expressed in terms of k_r, this appears probable. Would it not be desirable to investigate this question with great care before burdening the illuminating engineer with still another kind of room index?

1. Moon, Parry, and Spencer, D. E.: *Lighting Design*, 1948, Addison-Wesley Press, Cambridge, Mass., Chaps. V and VI; "Interflectance Calculations for Various Luminaires," *J. Franklin Inst.*, 252, 1951, p. 11-31.

2. Spencer, D. E., and Stakutis, V. J.: "The Integral-equation Solution of the Daylighting Problem," *J. Franklin Inst.*, 252, 1951, p. 225-237.

WARD HARRISON*: The authors have given us a most ingenious new concept of daylight illumination calculations — so new in fact that it took considerable mental discipline for me to hold clearly in my mind the meaning of "window index" and "illumination coefficient" both at the same time. On the third reading, however, my mental fog seemed to disappear and I want to congratulate Professor Biesele and his associates upon the constructive work that they have carried out. The fact that they have closely paralleled the widely used interior lighting computations should, as they have suggested, make the computations much easier for the illuminating engineer and the architect to follow. Inasmuch as their curves were obtained from some 400 tests covering different room proportions, reflection factors and sky brightness patterns, computations based upon them ought to be sufficiently accurate for all practical purposes.

I think they were wise in deciding to deviate somewhat from the familiar terms — room ratio and coefficient of utilization — possibly, however, the term "window ratio" would show a parallelism more clearly than "window index." Also I would like to ask whether window index is based upon the height above the plane or the height above the floor. Some of those present may recall that the Harrison-Anderson method started out with height above plane as the basis of room ratio but had to revise the figures to use height above the floor because their first and more scientific choice was so widely misapplied in the industry. Again, I think the term "room width" should be clearly defined, as rooms particularly offices in some instances have a greater dimension perpendicular to the windows than with them.

*Professor of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio.

**University of Connecticut, Storrs, Conn.

*Consulting Engineer, Cleveland, Ohio.

I have just one question in regard to maximum and minimum illumination. Do the minima for skylight and ground reflections always come at just the same point in the room so that it is necessary to add the low points, or is the actual minimum higher than this total?

H. B. VINCENT*: The need for simplification of calculation procedures is shown very effectively by the dozen or so factors mentioned as influencing daylighting results. As indicated, the problem is complex. However, the authors have been very successful in packing this complexity into a small number of reference charts. Instructions for use are simple and straightforward and it appears that anyone should be able to use them to make daylighting predictions.

I am unable to agree with the authors on the example which they work out. It appears to me that *E* avg., *E* min. and *E* max. should be 77.2, 36.3 and 143.7 footcandles, respectively. I have, however, checked the calculation method against several sets of illumination data for similar rooms and found that in all cases differences between calculated and measured lighting were within ten per cent.

It is noted that in the example cited the ratio of sky brightness to the brightness of a task of 70 per cent reflectance may be as high as about 30 to 1, pointing to the need for extension of the authors' methods to include calculation procedures for light-controlling devices which may be used effectively in the control of brightness contrast. It is hoped that they will favor us in the near future with a paper along these lines.

R. W. MCKINLEY**: These authors have really taken a cut at the ball and will, I suspect, be pursuing it around the park for several innings. I like particularly their idea of presenting daylighting design techniques in forms familiar to electric lighting engineers. Too often, the lighting engineer concerned primarily with electrical systems has acted as if there were an iron curtain over the fenestration wall beyond which his engineering interests did not extend.

When its development is complete, a system of this type should help interest the lighting engineers in evaluating the daylight contribution in an architectural design. Once they have made a daylighting evaluation, I believe the daylighting and electrical systems will be better coordinated and that the visual environments will be improved at no additional cost to any parties involved.

Since this is obviously the first step in a long program, I would like to make several suggestions for the authors' consideration. Perhaps they already have some of these thoughts in mind.

(1) Before publishing a "finished" procedure, I would suggest that they spot check their charts and tables by means of careful survey measurements in full scale rooms with natural terrain, shrubbery, furniture, etc., included to be sure that the "model factor" involved is not of large consequence.

Some of the model tests conducted under the direction of W. W. Caudill at Texas A & M indicated that variations between model and full scale data as large as 50 to 100 per cent were not uncommon. The full scale work on various fenestration systems conducted by Pittsburgh Corning in 1938 included tests of clear glazed windows both unshaded and shaded by blinds and roller shades as well as of various types of glass blocks. These data which were very carefully collected and which are quite familiar to Mr. Conover are immediately available for cross-checking. I refer of course to the paper presented to this Society by Baker and Rapp[1] at the 1941 National Technical Conference. Extensions of their work by the staff of the PC Daylighting Research Center have been published in the form of the PC Daylighting Nomograph in progressively improved arrangements which first appeared in a booklet on daylighting in 1950 and which more recently has been presented in *Engineering News Record*, May 3, 1951.

For example, the data for steel sash reported in Fig. 7 of the Baker-Rapp paper shows that at points 5 and 20 feet from the fenestration wall in a 28 x 28-foot room with ceiling, wall and floor reflectance of 78, 60 and 26 per cent, we would expect to measure 40 footcandles "maximum" and 14 footcandles "minimum" for an average sky brightness of about 532 footlamberts. I believe this average sky brightness would represent conditions comparable to those assumed in the example. In a longer, shallower room with more fenestration as assumed in the example, the Baker-Rapp data indicate that actual measurements would show a 55 footcandle maximum and a 19-footcandle minimum. If we stepped the data up another 10 per cent in line with the high reflectance of ceiling and floor assumed in the example, the values should be about 61 and 21 footcandles. These values based on full scale field measurements have been demonstrated to be reliable yet they do not approach even half the values predicted on the basis of the data collected in models. It is for this reason that I feel that field checks are necessary. If it is essential that the majority of the data for such a system be based on model measurements, though I doubt this need be true, it seems to me it should lean on the side of conservatism as did the original Harrison and Anderson system.

(2) I would like to suggest that the authors extend this approach to include a practical means of brightness prediction. Perhaps they would find the form developed for the *I.E.S. Lighting Handbook* based on the Helios Method of Moon and Spencer a good basis for reference. As reported in our Conference paper in 1951, the model theory correlation for daylighting has already been established by a cooperative research project undertaken by the PC Daylighting Research Center and Brown University.[2]

That this is quite possible at this stage of the game will be evident when you examine the brightness prediction charts which we have included in our PC Daylighting Nomograph. These brightness prediction charts are based on full scale field measurements.

(3) There is a real need in the field for a standard system of daylight analysis, evaluation and design and I would like to propose that the Society assign the chore of evaluating the various suggestions to the appropriate Committee so that as soon as a reliable technique applicable to all types of fenestration is available it can be published and thus be made available for general usage.

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H. S. BULL*: The authors are to be commended for this important contribution to the techniques of designing for

*Owens-Illinois Glass Co., Toledo, Ohio.
**Pittsburgh Corning Corp., Pittsburgh, Pa.

*University of Michigan, Ann Arbor, Mich.

daylighting. From my own work with model rooms I have a keen appreciation of the immense amount of effort that was involved in securing and correlating the data upon which the paper is based.

One question I would raise involves the validity of test data taken at five foot intervals if the room dimensions approach the lower limit of 10 x 10 mentioned in the paper. I assume the authors have checked this point carefully in their preliminary tests.

The likelihood of large variations in ground reflectance in the critical area near the window wall, along with the relatively short distance from this area to the window plane raises the question as to whether some sort of weighted average reflectance might not be necessary in predicting ground contributions. If so, how would the weighting be accomplished?

I hope that the authors will expand the scope of their studies to include the determination of empirical values of maximum and minimum brightness on the wall as functions of window index and illumination coefficient, so that certain critical brightness ratios might be computed from the design data.

BERNARD F. GREENE*: It is gratifying to note the increased interest and associated research in the field of daylighting. The large number of variables described by the authors no doubt has been responsible for some of this delay.

Everyone concerned with the design of lighting installations has looked forward to a method which can be readily used to obtain values of maximum, minimum and average illumination from daylight.

There are two questions we would like to raise:

(1) Will the method be applicable to multilateral fenestration and to prismatic control materials such as glass block?

(2) Where are the points of maximum and minimum illumination located? It is thought that the maximum illumination within a room would be at the window and equal to the illumination at the window multiplied by the losses due to the window. The value for maximum illumination in the authors' example differs considerably from what we have assumed would be the maximum value.

It would be interesting to see the authors' data checked against actual installations and against values obtained using the interflection tables of Moon and Spencer.

Some time ago, this writer made some preliminary studies to determine a method of daylight calculation. Checks were made against experimental figures based upon the proposition that the illumination varied as a function of the ratio of the window to floor area times the ratio of window height to room depth. We would be interested in learning if this approach checks against the experimental data obtained by the authors.

R. L. BIESELE, JR., W. J. ARNER, and E. W. C'&*158**: The interest in our paper shown by the various discussors has been quite pleasing to us as authors. At the same time, we have been all but staggered by the additional work suggested as desirable extensions of our investigations.

There appear to be no reasons why the method cannot be applied to all types of control devices, and to conditions of sunshine on the windows, as suggested by Professor Putnam and others, provided controls are employed whose interior distribution of light is relatively diffuse when subject to sunlight. This would include designs using prismatic controls, as well as those using louver controls or diffusing devices. It is also probable that a modification of the method could be developed for brightness prediction. That these things can be done, however, does not obviate the fact that they will take considerable doing, both in time and expense.

Dr. Spencer's suggestion that a mathematical approach could be made through the interflection method is welcome. Tentative attempts were made in the early stages of our work to apply the interflection method, but the asymmetry of the daylighting arrangements being considered introduced rather formidable complications. Consequently, we felt we could arrive at a useful technique more rapidly through our empirical approach, leaving the mathematical approach to those whose inclinations ran more in that direction.

This has resulted, as has been indicated in the discussion, in the use of a "Window Index" which may be an unnecessary addition to our list of indices. Our data, however, indicate that the asymmetry of the daylighting design will prevent the adoption of the usual room index or "domance." It can possibly be employed for rooms which are square, or whose long dimension is parallel with the window wall. At present, it does not appear applicable when the longer room dimension is perpendicular to the window wall. In this connection, we have used the term "width" to be that dimension perpendicular to the window wall. It might better have been referred to as the room depth, as has been done by several of the discussors. We have used also the height to the center of the window *as measured from the floor*, to correspond with interior lighting design practice, since we were aware of the confusion to which Dr. Harrison refers in his comments.

Assuming that our data are accurate, and every attempt has been made to make them so, the empirical and mathematical approaches should corroborate each other, unless the assumptions of the mathematical approach differ from the conditions of the empirical one.

The important point about the method, regardless of the procedure used in its development, is whether it checks with tests at full scale. The example in the paper was intentionally chosen to correspond with the test G2 6 of our earlier work, data for which was published in a previous paper by R. L. Biesele, Jr.,** and which is here compared with the example of the paper on a basis of equal total illumination incident on the window.

	Illumination, Ft-c		
	Average	Maximum	Minimum
Computed Example	74.6	120.9	44.8
Test G2 6 (Full size)	91	124	57

It is seen that the correlation is good, and that the method is on the conservative side. Dr. Vincent's difficulty in following our example is the result of the interchange of Figs. 4 and 5 in the preprint. The discrepancy between our data and the Rapp and Baker data which Mr. McKinley has mentioned is, we believe, the result of the addition of a considerable component of ground light in addition to the light from the sky in our example, which could possibly have caused a discrepancy of this order. We have been unable to check through this completely, however, since the Rapp and

*Consulting Engineer, New York, N. Y.
**Authors.

***"Daylight in Classrooms," ILLUMINATING ENGINEERING, July 1950.

Baker paper does not give a clear relation between the reading of the sphere and photocell, which they use as the basis of their data as presented, and the actual illumination incident on the vertical window.

An arbitrary choice had to be made on location of test points, and intervals representing five foot intervals at full scale appeared reasonable, for all except 10 foot room dimensions. For these, additional readings were taken at points representing 2½ feet from end or inside walls, and were included in the development of the curves of the paper. No data were taken closer than a point representing 5 feet from the window wall. There might be occasion to quibble over this decision, but this is the basis on which the data are presented, and we believe it to be reasonable.

The maximum value of illumination, in all cases including ground reflections, occurred at the point nearest the center of the window. The minimum value of illumination in all but a few cases involving high wall reflectances occurred at the test point nearest the front or rear of the inside wall. It is believed, however, that the method can be applied to multilateral designs by the addition of the data computed for the individual windows, provided the small error occasioned by adding a maximum occurring near the center of a window to a minimum occuring near its end, from a second window, is recognized. With normal reflection factors, it is believed that this error will be small, possibly under 10 per cent.

Professor Bull indicates one of the difficulties in dealing with the ground reflections, namely the shading of the ground area near the building by the building itself. This condition will have to be weighted judiciously by the designer.

Mr. Greene asks a question which emphasizes a point of considerable interest in our data, whether the daylight illumination varies "as a function of the ratio of window area to floor area times the ratio of window height to room depth." Our data indicate, however, and Rapp and Baker mention that theirs does also, that for the higher room surface reflectances coming into common use in schools and offices, the room illumination is directly proportional to window area, and independent of height of window above the floor, for most normal room configurations.

Lighting a Large Area Drafting Office

High-level illumination for a very large area with unusually high ceilings (18 feet) has been achieved by the continuous row technique shown, at the Airesearch Inc. drafting offices, Los Angeles, Calif. The engineering drafting office measures 125 x 220 ft. Four-lamp louvered luminaires, containing 96T12 lamps operating on 430 ma, provide 100 footcandles average maintained illumination. The luminaires are arranged in 13 rows of 27 units and 3 rows of 25 units making a total of 426. The rows are 8 ft on centers. Photo and data submitted by Illuminating Engineering Unit, Department of Water and Power, Los Angeles, Calif.

Techniques for Photography Of Lighted Streets

By T. KNOWLES
D. A. TOENJES

REALISTIC-appearing street lighting photographs require methods selected specially to handle low values and wide ranges of scene brightness. To be useful, general methods must be reduced to specific techniques that can be applied readily by a professional photographer without specialized knowledge of street lighting.

Realistic appearance must be accompanied by reproducibility. That is, pictures must be similar when produced by two photographers independently recording a given street lighting scene.

Few photographers have been willing to employ former procedures[1, 2] which, though producing excellent photographs, appear cumbersome and difficult. Instead, we have seen the all-too-familiar wide variety of print results, in which the same street lighting installation may appear either too darkly shadowed or too brightly lighted. In halftone reproduction or in lantern slide projection, the realism may suffer even further.

Briefly, the problem is this — to convey the proper pictorial impression, even though photographs and photo-mechanical reproductions are limited in their ability to record brightness values and brightness ranges.

Our purpose in this paper is to outline a procedure that has given us photographs that are reproducible, realistic in appearance, and not too difficult to obtain. The theories involved are not new, but are here combined in a workable method.

Review of Earlier Methods

Comprehensive basic studies have been carried out by earlier investigators. Some of these are indicated later in the list of references. Photographic representation has been tried according to various rules, as summarized by Hopkinson:[3]

(a) Correlation of subjective blacks. This is the method that Hopkinson advocates. Areas in the scene that appear completely black are rendered black in the reproduction. Threshold brightness — brightness so low as to be just barely discernible in the scene—should be just barely discernible in the reproduction when viewed under specified lighting conditions. Brightness ratios are duplicated as nearly as possible. This, in general, is the basis of our procedure.

(b) Maximum density range. This states that the highlights of the subject should be reproduced nearly white by the lowest density in the print. The deepest shadows would be shown nearly black by the highest print density. It can be done only by compressing the range of print contrast. But by such a rule, two street lighting scenes of widely different brightness ranges might be made to appear the same. This is not desirable.

(c) Correlation of highlights. Here the brightest highlight detail of the subject is reproduced by a just perceptible density in the print. This is done by raising or lowering average print density, rather than by adjusting contrast as in (b). But this too is unsatisfactory for appraisal because the eye judges a scene by average brightness, rather than highlights alone.

Outline of This Method

How should the photographer choose his equipment and materials for photographing lighted streets? Which of his techniques should he vary as he goes from one scene to another, and which should remain the same? What measurements must he make at each scene? The answers to these questions will be discussed separately and in detail later, but first let us set them down in outline form as shown in Table I.

Camera Equipment

One undesirable condition that always exists to some degree is the presence of non-image-forming light, or "flare light," in the camera. It adds an overall density to the negative, and detail is affected more adversely in the shadow areas than in the highlights. Jones[4, 5] confirms that this flare light depends largely upon the environment in which the photograph is taken. A typical lighted street is difficult in this respect, with its widely-spaced bright sources in a scene of otherwise very low brightness. The use of a coated lens helps to reduce the flare light. Shielding the front of the

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 8-12, 1952, Chicago, Ill.
AUTHORS: Application Engineering Dept., Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.

TABLE I.—Summary of Techniques.

Component	Adjustment for Scene		Description
	constant	variable	
Camera			
construction	x		view type with adjustable swings and rising and falling front
lens coating	x		coated lens desirable
lens focal length	x		preferably greater than the diagonal of the image size
aperture		x	selected according to scene requirements
Film			
characteristics	x		Super XX
exposure time		x	determined by brightness measurement and calculator (Fig. 1)
processing	x		14 min. in D-76 with intermittent agitation
Paper			
characteristics	x		Varigam projection paper
exposure time	x		determined by footcandles on paper in printing (negative removed)
processing	x		2 min. in Dektol 1:2

camera from nearby luminaires is also desirable. This can be done at the location, or preferably, by the use of a carefully-fitted lens hood that excludes light from any sources outside the field of view. During exposure the camera lens must be covered when approaching headlights come into the field, if bright streaks and possible added flare light are to be avoided.

Closely associated with this is the problem of "ghosts" — images of the light sources. These make the view type of camera necessary, for if these ghosts appear on the viewing screen, the adjustable front of the camera can usually be raised or shifted sufficiently to move them outside the image of the scene. Sometimes the front lens can be tilted slightly with the same result. The reduction of ghosts depends somewhat upon lens construction, and the photographer's experience will show him which are his best lenses in this respect. The lens must be very clean, and free from any scratches, to avoid "halation" around the luminaires in the picture.

Another problem is the loss of image illumination at increasing angles from the optical axis of the lens. This factor varies as $(\cos^4\theta)$, but other mechanical and optical considerations (*e.g.:* vignetting or foreshortening of the lens tube, and reflections at glass-air surfaces) cause further loss. This is affected by the choice of lens focal length and design, and by aperture.

To illustrate the variations, several lenses were tested. Relative effects, as measured from the resulting negatives, are shown in Table II.

Two identical grey surfaces of the same brightness were photographed so that the image of one

TABLE II.—Sensitometric Tests of Objective Lenses at $f/16$.

Lens	Focal Length	Image Size (normal lens rating)	Lens Angle Subtended by Diagonal	Coated Lens	Density Variation of Negative Image (approx. ratio, center:corner)
1	12"	8" x 10"	56°	yes	100 : 86
2	12"	8" x 10"	56°	yes	100 : 77
3	5.91"	4" x 5"	57°	—	100 : 84
4	5.31"	4" x 5"	62°	yes	100 : 85
5	4.25"	4" x 5"	74°	yes	100 : 75
6	8.5"	8" x 10"	74°	yes	100 : 71
7	8.5"	8" x 10"	74°	—	100 : 69
8	8.27"	8" x 10"	75°	—	100 : 64
9	3.5"	4" x 5"	85°	yes	100 : 56
10	6.5"	8" x 10"	89°	—	100 : 55
11	6.25"	8" x 10"	91°	yes	100 : 49

was located at the center and the other at the corner of the negative. This was done with each of the various lenses. The resulting image densities on each negative were measured, and their ratio computed for each lens. The test shows that this off-axis loss, in general, is least when the lens focal length is largest with respect to the image size. When only a *central portion* of the actual negative is used, the density at the corner of the picture will more nearly match that at the center, for equal scene brightnesses. Preferably the focal length should be greater than the diagonal of the final *picture* size. By this rule, the largest total lens angle subtended should be about 55° or less.

Taking the Picture

The camera should be positioned at the approximate height of a driver's eyes, and should be aimed to include the scene as he would see it from a driving lane.

The choice of aperture depends upon the scene requirements. If moving pedestrians and automobiles are to be included, possibly an aperture as large as $f/1.4$ or $f/2$ will permit an exposure short enough to limit such motion, particularly if the street is brightly lighted. But depth of field will have been sacrificed at such large apertures. When moving objects are not to be recorded, a more desirable aperture may be $f/11$ or $f/16$, in which case the foreground can be shown in better detail. The smaller apertures have the advantage, in addition, that they reduce the off-axis loss from vignetting.

The determination of exposure time depends upon both the film sensitivity and the brightness of the scene. In order to reduce the variables, we have selected a single film and have related the exposure time to the measured scene brightness and the aperture in a simple alignment chart (Fig. 1).

The brightness measurement requires an optical brightness meter with telescope-type field, such as

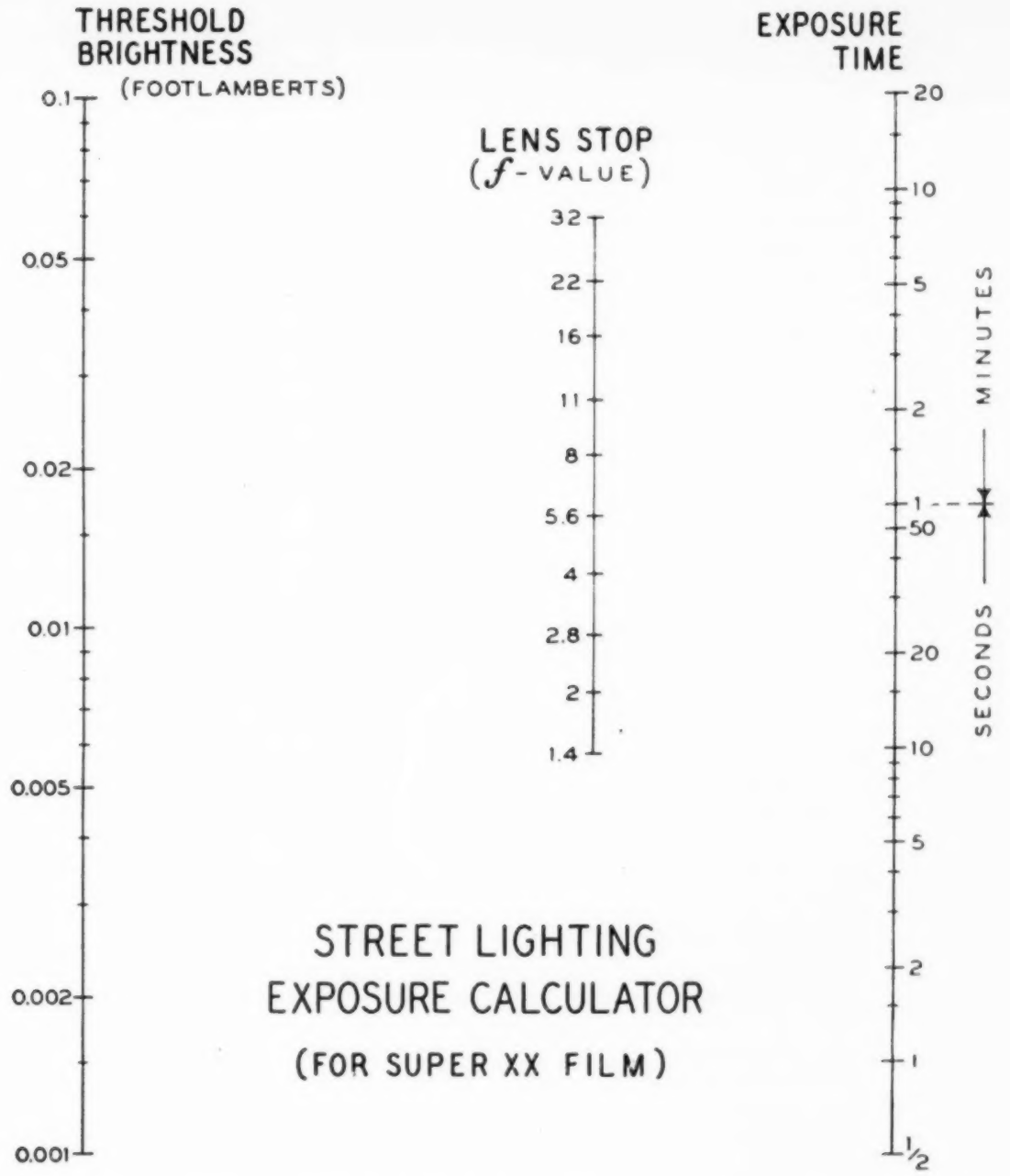

Figure 1. Exposure calculator. A straight line is laid across the three scales. Exposure time is determined from the measured threshold brightness and the lens stop.

the Luckiesh-Taylor Brightness Meter. The procedure is as follows:

(a) From close to the camera position, select a portion of the scene corresponding to "threshold brightness," so dark that details and brightness differences in this "threshold area" are just barely discernible. Usually such an area can be found in the shadows along curbs, behind parked cars, or between adjoining buildings that will appear in the photograph. In the case of very well-lighted streets or tunnels, it may be necessary to position some dark object in the field of view for this measurement.

(b) Measure the brightness of this threshold area. Indicate its brightness value in footlamberts and its exact position upon a sketch of the scene.

(c) Locate the brightness of the threshold area on the exposure calculator (Fig. 1), pass a straight line across the three scales, and read exposure time required for a selected aperture.

The calculator has been designed to result in a negative density of about 0.4 corresponding to threshold brightness. The film is developed to 0.8 gamma, and the lowest discernible scene brightness will remain on the straight-line portion of the density - log exposure curve. Such a curve is shown by Commery and Knowles.[6]

The procedure of using the straight-line portion of the *D—log E* curve, and avoiding the "toe" of the curve, is not necessary in many photographic applications. But in street lighting photographs we found it helpful in reproducing details in the near-threshold areas.

The major difference between our representation and that of Hopkinson[1] can now be clarified. Each depends basically upon the "correlation of subjective blacks." But Hopkinson retains the proper brightness ratios as closely as possible throughout the limited print-density range, at the sacrifice of the lower scene brightnesses which may appear completely dark on the print. He states, ". . . although detail is visible down to this lower brightness limit, it becomes vague at about ten times that limit, so that even if detail could be portrayed by the printing paper down to the limit, little gain in the perfection of the representation would be obtained."

Our alternative is to compress the brightness ratios (by developing to a gamma less than unity) but to retain the lower scene brightnesses as still discernible on the print. We feel that this is justified because the effectiveness of street illumination is largely appraised by visibility in the darkest areas.

It should be noted here that the design of the calculator was based upon lighting by filament lamps. If another type of light source, such as mercury or fluorescent, is used in the scene to be photographed, the exposure time read from the calculator may have to be reduced by some corresponding factor. This can be determined by experiment.

Techniques for Printing

An ideal paper print would reproduce the brightness range of the original scene. But this is not possible in the usual street-lighting scene, for while Hopkinson[1, 3] indicates that the eye can perceive scene brightness ratios as high as 3000 : 1, the range for the negative is about 125 : 1, and that of the paper about 60 : 1. So we must attempt instead to give *as closely as possible* a correct *subjective* picture of the original scene.

The maximum *reflectance* range actually obtained in the final paper print is about 4 per cent to 80 per cent. This is a ratio of 1:20. In order to still show details throughout the wide range of scene brightness, we compress it to fit into the limited reflectance range of the paper. On the one hand we must avoid too "contrasty" a print, in which the brightest portions of the pavement surface would appear as bright as the luminaires themselves; on the other hand, we should like to show our deep shadows more nearly black than grey.

A dual-contrast printing yielded good gradation in the threshold areas, and at the same time helped to keep those areas acceptably dark in the resulting print. Such a technique is described by Potter.[7] Two filters were used in succession, on "Varigam" high-speed projection paper. The first printing, 20 sec. through a low-contrast filter (#1), gives overall detail including the highlights. The added printing, 5 sec. through a high-contrast filter (#10), darkens the shadow areas and still retains their detail and separation, without materially darkening the bright tones. With the negative removed, the filament lamp's illumination upon the printing surface was 2.2 footcandles; at other footcandle levels, one should adjust his printing times accordingly. Experiments with other single filters between the #1 and #10 extremes of contrast, and with other papers, seemed to fall short of the results obtained with this combination.

The printer used was an 8″ x 10″ Elwood autofocus projection printer. Image size used in printing was 1.5 times that of the negative.

In order to determine the approximate print reflectance that should represent any scene bightness, a second alignment chart (Fig. 2) has been developed.

First locate the measured threshold brightness of the scene upon the center scale. Then locate on the left-hand scale that same value, or any other scene brightness that may also have been measured when the photograph was taken. Pass a straight line through these two points, and it will intersect the right-hand scale. At that point you can read the approximate reflectance of the print for the corresponding position in the scene, if the procedure has been carried out successfully.

This chart in its simple form is made possible by our using the linear portion of the *D—log E* curve, as mentioned earlier. The chart's accuracy is limited by the several unavoidable factors that affect negative density. These include flare light, lens

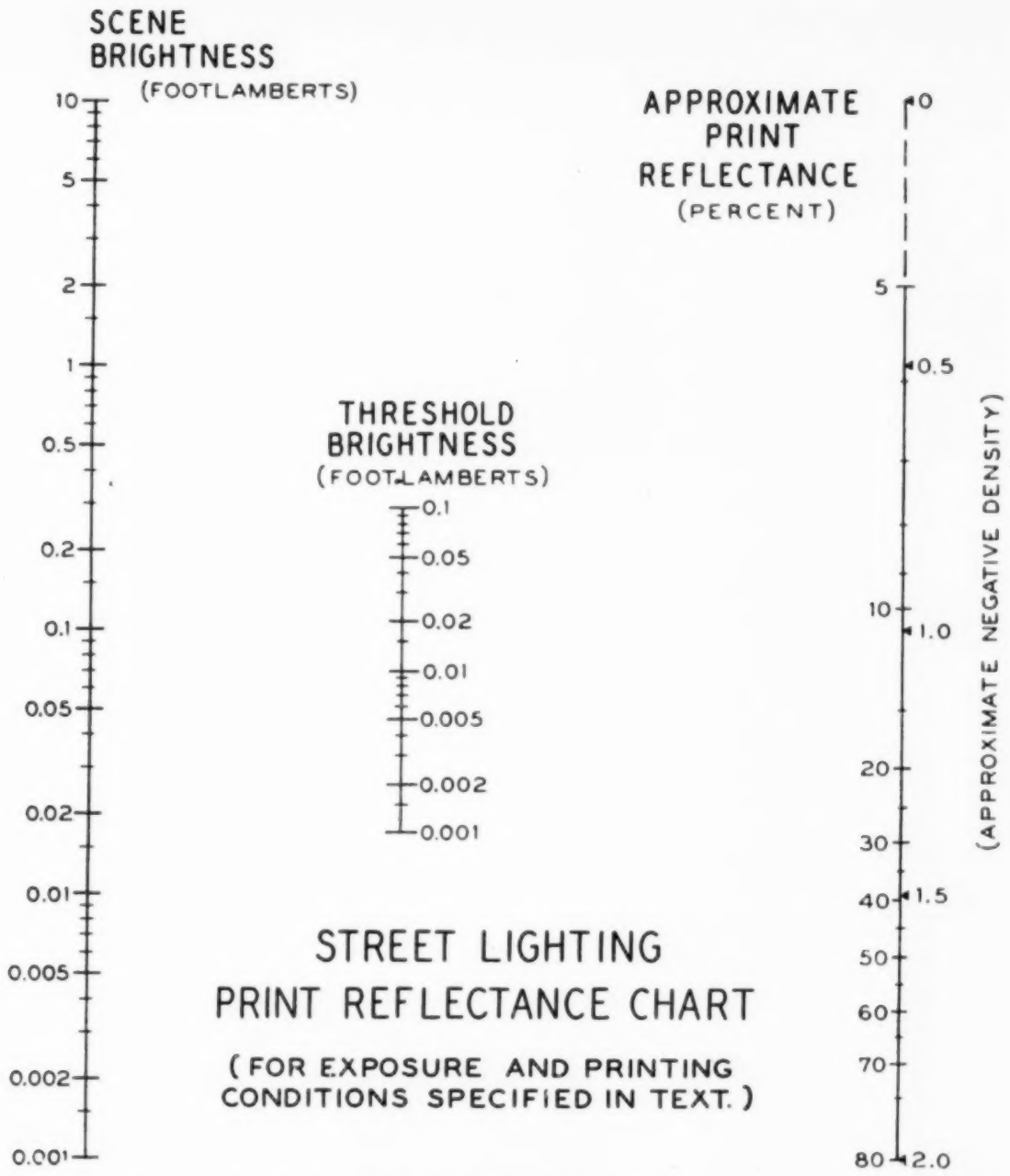

Figure 2. Print reflectance chart. A straight line is laid across the three scales. Desired reflectance of any part of the print is estimated from the corresponding scene brightness and the measured threshold brightness.

transmittance, and off-axis loss of image illumination. But these factors should not prohibit its use for an approximate check upon print reflectances.

Results — Uses and Limitations

The purpose of this study, as we stated earlier, has been to outline a procedure for obtaining street lighting photographs that are both realistic and reproducible. The realism has been approached by subject appraisals of prints made by modifications of the various techniques. Reproducibility requires that the method be standardized, simple, and specific.

The method as outlined applies only to repro-

Figure 3. Reproduction of residential street. Average horizontal illumination, 0.31 footcandles. Measured threshold brightness, beside curb ahead of parked car, 0.007 footlamberts. Exposure: 10 min. at *f*/11. Proper viewing distance for this reproduction: 10½ inches.

ducing realistic *prints*. For lantern slides, halftone reproductions, or movies, it should be modified as will be described further on.

When we prepared the alignment chart (Fig. 1) relating exposure time and aperture to the threshold brightness, we found that the scales were not quite the same as would be used for photography of scenes at ordinary room brightnesses as outlined by Commery and Knowles.[6] This can probably be attributed to the failure of the reciprocity law to apply exactly over a brightness and exposure range wide enough to embrace both lighted interiors and lighted streets. However, serious error will not result from assuming that it holds true over a more limited range such as that used in Fig. 1 for street-lighting scenes only.

One limitation, as mentioned earlier, is that the scale of brightness ratios has been compressed in order to keep the lowest brightnesses discernible on the print. But even with this adjustment, the limited range of photographic densities means that the bright luminaires will nearly always be completely "off scale" on the print, simply appearing as white as the printing paper. Hopkinson[1] suggests a method of masking and transillumination to add realism to the luminaires if that is essential.

How shall we view the print to get true perspective? In order to keep our eyes' subtended angles the same as in the original scene, the viewing distance should equal the focal length of the camera lens, multiplied by the linear enlargement that may have been used in printing. For example, if a 16-inch viewing distance is desired for the final print, and the negative was taken with a lens of an 8-inch

Figure 4. Reproduction of medium-traffic street. Average horizontal illumination, 0.77 footcandles. Measured threshold brightness, on nearest side of building at right, near sidewalk, 0.024 footlamberts. Exposure: 2 min. at *f*/11. Proper viewing distance for this reproduction: 10½ inches.

focal length, then the linear enlargement is computed as:

$$\text{linear enlargement} = \frac{\text{viewing distance}}{\text{focal length of camera lens}}$$

$$= \frac{16''}{8''}$$

$$= 2 \text{ times.}$$

A reasonable viewing distance for a hand-held photograph is from 15 to 18 inches. Viewing distance may well be specified in the caption of a photograph intended for critical comparison.

Room illumination levels in which the prints were viewed were of the order of 50 footcandles. Hopkinson[1] asserts that appearance remains nearly constant throughout a range of illumination from 5 to 500 footcandles. Our observations, however, show a marked difference in overall appearance through that very wide range. We would suggest a more moderate range, such as 30 to 60 footcandles. Viewed under only the darkroom light, of course, the prints would appear too dark.

The border of the picture does not greatly affect its actual appearance, although a grey or black border does seem to distract the eye less than does a border of white.

Projection Slides

Lantern slides for projection present some of the same problems as photographic prints, but in different degrees of importance and with a few new factors thrown in.

Proper perspective is a more important consideration here than in the case of photographic prints, because it is harder to attain. When you hold in your hand a photograph of a lighted street, you can bring it forward or move it back until it "seems right" to your eyes. But when you are seated in an auditorium before a projection screen, there is nothing you can do to adjust perspective, short of changing your seat. Perspective, for an observer at an average viewing distance from the screen, can be gained by correct choice of the portion of the negative used in making the slide. The size of this portion of the negative is related to the size of the projected picture, the focal length of the camera lens, and the distance from the viewing position to the screen, as follows:

$$W_n = \frac{W_s}{D_v} \times \text{F.L.}$$

where: W_n = width of portion of negative used (in.)
W_s = width of projected picture on screen (ft.)
D_v = viewing distance from screen (ft.)
F.L. = focal length of camera lens (in.)

For example, an average viewing distance of 20 feet is typical of small auditoriums. With a screen 8 feet wide, of which the full width is used, and a negative taken with a camera lens of 12-inch focal length,

$$\begin{bmatrix}\text{width used of neg.} \\ \text{(inches)}\end{bmatrix} = \frac{8'}{20'} \times 12''$$

$$= 4.8'' \text{ width used of negative}$$

The photographic slide can be designed if two conditions are known. One is average viewing distance — to establish proper perspective, as just shown. The other is average screen brightness — to establish proper slide density.

Even with proper perspective, the projected picture can lose all realism if it appears too bright or too dim on the screen. As would be expected, screen brightness depends first of all upon the footcandles delivered to the screen's surface by the projector with the slide removed. Footcandles vary with the projection lamp wattage, the type of projector, and its distance from the screen.

But a specification of footcandles alone is not sufficient. The angle from which the observer views the screen — especially with the modern "beaded" screen surface—has a great effect upon the screen's brightness in his direction. With increasing angle between the axis of projection and the observer's line of sight, the screen appears less and less bright. Measurements with a beaded screen show that the screen brightness falls off to less than half when the angle is increased from 0° to 20°, and to one-fifth at about 45°. With a plain white non-glossy surface, these differences are much less.

We have designed our slides for an average screen brightness of about 10 footlamberts. If screen brightness is too high, it can be reduced by a variable voltage control on the projection lamp, or by a restricting aperture over the front lens of the projector. General lighting in the auditorium affects the appearance of the projected picture, particularly in the case of the darker slides. We found that 0.04 footcandles illumination on the screen's surface (giving 0.03 footlamberts screen brightness) was about the top limit. Higher values tended to "wash out" the picture. Horizontal illumination at seat level was about 0.1 footcandle under these conditions.

We obtained a slide density giving the best appearance with this 10-footlambert screen brightness by preparing the slides as follows: Medium-contrast lantern-slide plates were used. Negatives were those described earlier. Printing exposure with a filament lamp was 16 footcandle-seconds (for example, 12 seconds with 1.3 footcandles measured at the

plate position with the negative removed). Development was 1.5 minutes in Dektol 1:6 solution.

Slides considered satisfactory for projection were also viewed on a diffuse light-box of 3 footlamberts brightness. They appeared the same as the original scene, judging by barely-perceptible details in the threshold area. This is a way to appraise slides in the photographic darkroom, before projection. When this is done, the surrounding bright area must be masked, and room illumination must be low — 5 footcandles or less.

Halftone Reproductions

The range of density is usually shortened when a print is reproduced by the halftone process. That is, separation of tones is lost in both the dark greys and light greys. For realistic reproductions, the negatives and prints are prepared by the technique described previously. But the print must be selected carefully to make certain that the contrast is satisfactory, especially in the darker areas. The engraver should be cautioned to make his reproduction as nearly like the original photographic print as possible. Details in the darker areas should neither be lightened nor lost.

Movies of Lighted Streets

Two years ago, motion pictures of the Brooklyn-Battery Tunnel[8] and other tunnels were taken from the driver's position in a moving automobile. The details of procedure were not published. Based on this experience and further studies, we conclude that reasonably satisfactory movies can be taken of well-lighted streets. A suggested procedure:

Film	Super XX Cine Kodak 16-mm
Lens	*f*/1.4 coated, 25-mm focal length
Exposure	8 frames per second (1/15 second exposure per frame)
Vehicle speed	approximately 8 miles per hour
Camera position	slightly behind driver's normal eye position
Projection speed	16 frames per second

Even with these facilities for high-speed photography, detail is generally lost in the darker areas—those below about 0.3 footlamberts. With the coated lens, halation around oncoming headlights is not objectionable except in the unusual case when one is aimed almost directly into the camera. When shown at 16 frames per second, the speed of all oncoming and passing traffic doubles and is obviously distorted. However, we found no way to obtain satisfactory pictures at more than 8 frames per second. In spite of these limitations, such movies are helpful in portraying a driver's impression of shifting brightness patterns.

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6. Commery, E. W., and Knowles, T.: "The Photography of Residential Artificial Lighting Effects," a paper presented at the National Technical Conference of the I.E.S., Aug. 27-30, 1951, Washington, D. C. Abstract: ILLUMINATING ENGINEERING, Vol. XLVI, No. 9, pp. 485-486 (September 1951).

7. Potter, R. S.: "Gradation Control," *Photo. Soc. America Jour.*, v. 18, n. 5, pp. 313-317 (May 1952).

8. Geenens, L., and Reid, K. M.: "Lighting of the Brooklyn Battery Tunnel," ILLUMINATING ENGINEERING, Vol. XLV, No. 11, pp. 697-704 (November 1950).

DISCUSSION

R. G. HOPKINSON*: Photographers have debated endlessly the problem of the true photographic rendering of luminosities, but their debates have led to no result of practical value, because they were not concerned with a practical problem. It has been left to engineers to devise photographic techniques of engineering value to permit the true rendering of the luminosities of lighting installations. However, the photographic discussions have been of great value in that they have supplied the foundations on which the engineer has been able to build.

The paper by Mr. Knowles and Mr. Toenjes reopens the specific problem of the correct rendering of the luminosities encountered in lighted streets, and I have found it of great interest to approach the problem again myself in the light of their work. I am gratified to find that we are all in agreement on most of the basic matters, and it is encouraging to find much of what was relevant as long ago as 1935 worthy of recapitulation today.

The differences between the technique described by the authors, and that described in my papers should be examined in two ways: first, does it give better quality photographs, and second, can the method be more easily assimilated and employed by the laboratory technician? I should like to plead, in favor of the earlier method, that we found it nothing like so fearsome in practice as has been suggested. It was reduced to a rote of calculators which could be employed successfully by a good laboratory assistant. It is still being used without modification, and, as far as I know, with success.

I should be interested to compare the results obtained by the two methods. When the first variable-gamma paper was marketed in England, I experimented to see if any advantage could be gained over the bromide papers then available. There did not appear to be any which was not offset by the increased difficulty of manipulating the variable-gamma material. (It must be remembered that in England reproducibility of results for standardizing purposes is

*Abbots Langley, England.

equally as important as truthfulness. One hundred prints may be needed for a report, within very close density limits. These limits did not appear to be maintained as closely with the variable gamma material as with the bromide or chlorobromide papers.)

It would be of value to see a characteristic curve relating the original brightness on the street (on a logarithmic scale) with the reflection densities on the print, for a standard soft bromide, or chlorobromide paper, and for the variable-gamma paper. This characteristic curve should show objectively what advantages had been gained; the subjective impression of the comparison between the two would, of course, also be valuable. The objection to the technique which I described, although theoretically to be found in the shadows, does not appear to cause trouble, due in some measure to the properties of the eye at low brightnesses (quoted by the authors on page 52, paragraph 3) and due also to the shape of the paper emulsion characteristic, which permits some sort of shadow rendering which, to the eye at those low brightness levels, appears fairly adequate. This is demonstrated by the fact that a transparency, which does not suffer from these disadvantages, is only a little more truthful than the print. Is the complication of the variable-gamma paper justified, since we are, after all, searching for simplification?

I should be surprised if the method described by the authors for the preparation of lantern slides will be found sufficiently precise. The densities of the lantern slide must be determined with as great accuracy as those of the print, if the slides are to be projected in succession, without separate adjustment of the screen brightness. The visual difference between an installation with 300-watt lamping and with 500-watt lamping may call for a density difference of only 0.08 on the print on the lantern slide. Can your emulsions be relied upon to that accuracy with the technique described by the authors?

Techniques such as those described in the paper are needed for two reasons at least: one, to serve as a record of the visibility obtaining on the street, and the other, to enable the characteristics of the installation to be demonstrated to others with a certainty that a misleading impression will not be given. Both these results can be achieved by simple methods such as that which was described in the abstract published in 1946 (Reference 1 of this paper). This amounts to no more than correct exposure and standardized development, such as every enlightened photographer practices nowadays, together with a simple standardized printing technique which, however, *relies on the skill and integrity of the photographer in choosing the correct print.* All the gadgetry and so-called cumbersomeness of the complete technique is merely to eliminate this personal factor, and to make the method objective and independent of the personal judgment of the photographer. If the preparation of street lighting photographs were acknowledged to be a task demanding high grade scientific skill, in the same way as is the preparation of a photometric survey, and not merely a job for the general photographer, the integrity of the result could be assumed, and the need for all the densitometry, etc. swept away for all jobs except those of the very highest precision. I do urge you to consider this approach seriously. Objectivity can be a very expensive luxury.

I am grateful to the authors for the opportunity to comment on their paper, and am glad that interest is still keen on this problem.

D. M. FINCH and R. B. MARXHEIMER*: A realistic, reproducible photographic representation of street lighting at night to a light-adapted observer constitutes a complex problem. (Ref. 2.)

Messrs. Knowles and Toenjes have developed a standardized and simple technique which can be utilized by most amateur photographers. To achieve this degree of simplicity, certain assumptions had to be made, as for example "to compress the brightness ratios but to retain the lower scene brightness as still discernible on the print." When one evaluates the effectiveness of a street lighting installation it is necessary to know the minimum scene brightness, but we also are interested in the maximum and intermediate brightnesses to visualize the brightness pattern. But since the vehicle driver is concerned primarily with the appearance of the roadway, it is not too important that "the bright luminaires nearly always will be off scale on the print," except when evaluating discomfort glare.

One question which seems important is the relationship between eye adaptation and threshold brightness. Since the threshold brightness is required in order to use the technique and is a function of adaptation level, we would like to know how the adaptation level is taken into account in the technique.

The photographic technique described is mainly useful for taking still photographs and as such should be helpful in getting more precise renditions of actual conditions. The authors have mentioned a technique for making motion pictures. This would be an excellent field in which to extend the investigation.

T. KNOWLES and D. A. TOENJES**: We appreciate the comments of the discussors. We are particularly indebted to Dr. Hopkinson for preparing a communicated discussion in the midst of a crowded schedule.

Dr. Hopkinson regards his earlier method as being quite usable in practice, when the calculations are carried out by a good laboratory assistant. However, it has not found such use in the U. S., even though it was actively promoted by many people here — notably the I.E.S. Committee on Street and Highway Lighting. In fact, his method was digested in ILLUMINATING ENGINEERING in an effort to further its use. We hope that our method will prove simpler and thus helpful to photographers in more generally obtaining the realistic appearance in which our British friends have so often surpassed us.

He questions the need for variable-gamma printing paper and the dual-contrast method of printing. As indicated, this was tried in comparison with several other papers, and we found that we achieved a fuller reflectance range and better separation of the dark tones. Even a representative of a photographic supplier prepared a number of prints in our laboratory in an effort, by the conventional method, to equal these results. But in a subjective comparison of unlabeled prints, the choice was of the dual-contrast prints each time. Granted, the difference was not great, and a preliminary comparison of the sensitometric curves did not yield an obvious explanation. Similar curves are shown by Potter (Reference No. 7). Our suggestion at present would be a similar subjective comparison of print results. In addition, Fig. 2 will be a useful check in correcting for the effects of minor differences in equipment or materials.

*Associate Engineer, Institute of Transportation and Traffic Engineering, Univ. of California, Berkeley, Calif. and Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif., respectively.
**Authors.

He asks if our method for the preparation of lantern slides is sufficiently precise. This will have to be determined in practice, and we cannot yet give an unqualified answer. However, in our preliminary checks, two different laboratory technicians used this method with the same negative and prepared slides that were satisfactory duplicates, more than a month apart with different emulsions.

Also he asks, do we urge techniques that are as nearly objective as possible; why not rely on the judgment of the photographer? In this country, that is what has generally been done, and we have all seen the over optimistic reproductions of relighted streets. For satisfactory results, the photographer would need to combine unusual skill with a high regard for fidelity. But our purpose here has been to outline a method that can be employed more widely by professional photographers without specialized experience in street-lighting photography. It is toward that end that these techniques have been combined.

Professor Finch and Mr. Marxheimer ask how eye adaptation is related to threshold brightness in the techniques described. Such a relationship is charted by Hopkinson (Reference No. 3) and others.[1] In this case, however, the adaptation level is taken into account because the aperture and exposure are determined from the threshold brightness itself for a given scene.

1. Nutting, P. G.: *J. Opt. Soc. America*, 1920.

Silhouette Lighting of Small Diameter Wires

Discussion and Rebuttal of paper by Willard Allphin

(Published October 1952 ILLUMINATING ENGINEERING)

E. M. Strong and C. L. Cottrell*: It may be of interest to describe the modification of the c b meter here used as compared to the one described previously.

This modification affords a fixed relationship between the brightness of the projected luminous area and the brightness of the background of the visual task. It is accomplished by periscopic means using the target background as the source of light for the projected area. By laboratory measurement the brightness of this area is determined as a definite fraction of the background brightness and this factor is a constant for the instrument, the constant ρ which appears in the contrast sensitivity factor.

The optical arrangement of the meter is shown in the accompanying diagram.

In addition to the advantages afforded by the fact that no power source is needed to supply current to the lamp used in the earlier model, and also that no preliminary brightness measurements of the background are needed, there is considerable further advantage in using this instrument for threshold measurements when the visual tasks have a colored background, since the projected area must have closely the color of the directly viewed background.

There is one limitation in the use of this instrument. This is when the background does not afford a large enough area of uniform brightness devoid of obscuring detail. For some tasks the background does not afford a sufficiently large area of uniform brightness, due either to the inherent size or because of obscuring detail, as, for example, a printed page. This limitation is a serious one, but it should be noted that a combination instrument can be built, which would permit use of either form as the target may require.

*Cornell University, Ithaca, N. Y.

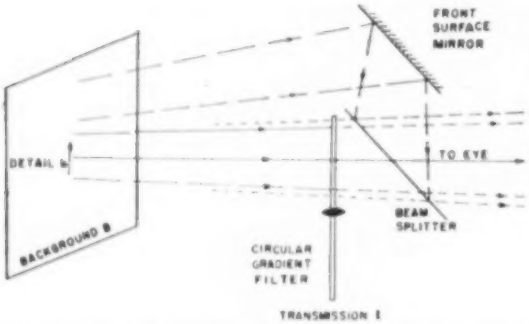


Diagram of meter to determine the contrast sensitivity factor of a visual target.

As target appears to eye.

A. A. Brainerd*: The author of this paper has brought us a very interesting and accurate analysis of the seeing task involving very fine wires. His conclusions that silhouette lighting is the only logical solution of the problem are apparently open to question since these investigations record comparative studies of front lighting from a highly directional source with almost completely diffuse low brilliancy back lighting. While the use of the self-luminous back ground is one acceptable solution, I am of the opinion that no lighting engineer would be inspired to light this task with a projection spot. It happens that I have encountered this problem in practice and have found that front lighting from a large area low brilliancy light source is quite satis-

*Philadelphia Electric Co., Philadelphia, Pa.

factory. Certainly, high level diffuse lighting is easier to apply and maintain.

The tendency toward localized treatment for specific seeing tasks has the effect of distracting our attention from the main job of providing a comfortable indoor environment for carrying out our daily tasks. I, for one, would like additional test data before conceding that silhouette lighting is the only solution, or even the best solution, of this particular seeing problem.

GLENN A. FRY*: The paper emphasizes the need for paying attention to direction of illumination as opposed to sheer quantity of illumination. It also demonstrates for the task at hand that the presence of a bright surround is not important for contrast sensitivity, and the use of a bright surround has to be justified on some other basis.

In order to relate the data to other data the absolute value of p should be specified. It is implied, but if it is true it should be explicitly stated that p and t represent ratios of brightnesses seen through and without the instrument.

The location of the spotlight and the eyes and meter with respect to the wires should be specified because these things determine the presence and shape of highlights on the cylindrical wires. The same thing applies to the design of the general lighting. A magnified photograph of the wire might show the types of highlights present. The question remains whether some other type of front lighting might not have been so bad. It would probably be easier to find the answer to this at the theoretical level than by a cut and try method.

DOMINA EBERLE SPENCER**: Mr. Allphin has demonstrated that the Cottrell meter is useful for telling which of two visual tasks is easier to see: a fine wire silhouetted against a uniform background to give maximum contrast, or the same wire lighted in such a way that contrast is reduced. The results are as would be expected from experience. The advantage of the Cottrell meter is that it makes the comparison between two different visual fields quantitative and can be applied to complex situations which are not susceptible to theoretical analysis. The disadvantage is that the meaning of the quantitative readings is far from clear.

Another way in which Mr. Allphin might have attacked his problem is to use the "delos" method.[1] The data of Hecht and Mintz[2] apply to a fine wire viewed in silhouette against a uniform field and are fitted by the curve

$$\alpha = \frac{1.950 \times 10^{-6}}{H_A} (1.433 + H_A^{1/2})^2$$

where α = angle subtended by wire (radian),
H_A = adaptation helios (blondel).
The corresponding *delos* is

$$\Upsilon_w = \frac{H_A}{(1.433 + H_A^{1/2})^2}$$

Calculation with these equations reveals that Mr. Allphin's choice of 210 footlamberts (or 2260 blondel) corresponds to a delos of 94 per cent. An increase to 5000 blondel gives a delos of 96 per cent — 2 per cent better vision for 100 per cent increase in expenditure. As the task is far from a threshold task (roughly 100 times minimum perceptible according to the Hecht-Mintz data), it is not surprising that the factory workers are satisfied with the 2260 blondel background.

Perhaps a word of caution should again be injected on the use of the Cottrell device with non-uniform surrounds. It appears that the observer who peers through the eyepiece is in a very different visual situation from the worker who assembles miniature tubes. As the background in all cases subtends a diameter that is over three times that of the fovea, the adaptation helios of the eye will be within 5 per cent of that of the work when the eyes are kept fixed on the center of the task. But if, as in Mr. Allphin's examples, the central field is about 10 times as bright as the surround the state of adaptation and the delos may change by a factor of 10 when the worker allows his eyes to stray from the work. When he looks back to the work, before his retina has time to readapt, the delos will be not 94 per cent, but 9 per cent. With a safety factor of 100 in size, he can probably still find the wire, but a certain visual strain is associated. It is such effects which are not susceptible to study by the Cottrell meter. It would be interesting to see Mr. Allphin extend his study of visually difficult factory situations to the study of patterns of eye movements with the Lion meter and to the study of cost of seeing with the electro physiological instrumentation he has made such good use of previously. Here lies a more important question than any that can be solved with a meter that neglects eye movements and the effect of a dark or glaring surround.

1. Moon and Spencer, *Lighting Design*, Addison-Wesley Press, Cambridge, Mass., 1948, Chap. 8.
2. S. Hecht and E. V. Mintz, "The visibility of single lines at various illuminations and the retinal basis of visual resolution," *J. Gen. Physiol.*, 22, 1939, p. 593.

E. A. LINSDAY*: The author presents an interesting study which illustrates the importance of analyzing a task in order to specify light and lighting. The results are in accord with previous work on visibility.

The brightness difference concept is outlined in another paper** "Brightness Difference — A Basic Factor in Supra-threshold Seeing" by S. K. Guth, A. A. Eastman, R. C. Rodgers. For any *specific* task, the greater the brightness *difference* the higher the visibility. In the case of theoretically perfect silhouette seeing the object brightness is zero and the contrast must therefore be 100 per cent, regardless of the brightness of the background. With front lighting these perfect conditions no longer hold and visibility is reduced.

Separate control of the wire brightness and background brightness is the best way to achieve high visibility. Knowing the reflectances involved, the brightness difference can be calculated for any specific footcandle level. For the example cited on page 549, If reflectance of Wire (R_w) equals 76 per cent, luminous background brightness (B_b) equals 40 footlamberts, general illumination (E) equals 40 footcandles, added background brightness (B_a) equals 20 footlamberts.

Brightness of Wire (B_w)
Reflectance of Wire (R_w)
Brightness difference ΔB
$\Delta B = (B_b + B_a) - B_w$
$(B_w) = ER_w$
For silhouette lighting $ER_w = 0$, $B_w = 0$, $B_a = 0$
$\Delta B = 40 + 0 - 0 = 40$
For front lighting $\Delta B = 40 + 20 - 40\ (.76) = 60 - 30 = 30$
(Front lighting lower than Silhouette)

*Ohio State University, Columbus, Ohio.
**University of Connecticut, Storrs, Conn.

*General Electric Co., Nela Park, Cleveland, Ohio.
**To be published.

Another lighting method takes into consideration the finish of the wires. For example high light reflections on the wires with a dark background behind them may be used. Under actual working conditions the position of the wires in perspective is important. It would seem that reflection would make positioning easier.

Another factor of considerable importance is that of working under conditions of high brightness contrast in the peripheral field. This condition would exist with a trans-illuminated panel with everything else in the visual field relatively dark. Would it be easier to produce comfortable seeing conditions by controlled reflections with the background of the same order of brightness as the general surround?

WILLARD ALLPHIN*: May I thank all of the discussors for their pertinent comments. I believe Mr. Brainerd has overlooked the fact that while curve B is for front lighting from a spotlight, curve D represents a typical industrial situation where the front lighting is from general diffused sources.

*Author: Sylvania Electric Products Co., Salem, Mass.

Dr. Fry is correct in assuming that p and t are ratios of brightness seen through the instrument to brightness seen without the instrument. For the instrument used, p was 28 per cent. I should have mentioned in the paper that the wires were all dark in color.

It is interesting to see that "delos" calculations of Dr. Spencer agree with the results found experimentally.

In reply to Dr. Spencer's last paragraph, it is well known that it would be desirable to increase the brightness of the general surround in order to reduce contrasts. The Cottrell meter was being used in my project solely to indicate what immediate background brightness was desirable from a standpoint of contrast sensitivity.

Mr. Linsday has misunderstood my example on page 569 (October I.E.). 76 per cent was the reflectance of the small spot background, not the wire. I do not know the reflectance of the wire and would not know how to measure the reflectance of any object so narrow.

In reply to Mr. Linsday's last paragraph, the operators do not find the background brightness of 210 footlamberts uncomfortable under their customary adaptation.

Reflectorized Mercury Lamps and Their Industrial Applications

Discussion and Rebuttal of paper by E. B. Noel and E. A. Linsday

(Published October 1952 ILLUMINATING ENGINEERING)

J. R. JONES*: Reflector mercury lamps are a new lighting tool and the lighting industry has not yet had an opportunity to become familiar with their application. The industry should appreciate the service the authors have rendered.

Reflector mercury lamps have several unique features that should be given consideration when designing installations around the lamps. The features are:

1. Low initial installation cost.
2. Good maintenance (illumination is not reduced significantly because of dirt).
3. Relatively long life.
4. High candlepower (compared to conventional equipment) near 90 degrees.
5. Relatively small size and extremely high brightness.

Items 1, 2 and 3 are always advantages. Item 5 is almost never an advantage.

Item 4 is controllable (to a degree) by the illuminating engineer designing the installation. High candlepower in the 60 to 85 degree zone produces high levels of vertical surface illumination. That is good. But high candlepower in this zone also means low system efficiency in relatively high narrow areas (too much light lost on walls and too little directed to the working plane), and too much direct glare in long and wide areas. At this point the engineer designing the installation must decide whether the high vertical surface illumination is worth the cost of low system efficiency and direct glare. If vertical surface illumination is not worth the price, reflectors can be installed and the candlepower above 60 degrees thus greatly reduced. This is the policy recommended by the authors, and for the R1 and the RC1 the writer quite agrees. However, in adopting this policy it must be recognized that the vertical surface illumination will be reduced and the work plane illumination will be increased somewhat if the reflectors are clean. But, if reflectors are to be used, conventional lamps have several advantages over reflector lamps — longer life, higher lumen output, and lower lamp cost.

For use in high narrow areas where reflectors are needed less (to minimize glare) lamps or equipment with a narrower distribution than that of the R1 and RC1 would direct more flux to the work plane (nearly twice as much in some cases) and approximately 30 per cent less on vertical surfaces. Again it becomes necessary to decide — how much is vertical surface illumination worth?

*Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.

E. B. NOEL and E. A. LINSDAY*: The authors appreciate Mr. Jones' discussion which serves to summarize the main advantages and disadvantages of mercury reflector lamps for general lighting applications.

The authors would again like to emphasize the importance of good vertical illumination and high maintenance factor. The distribution of the mercury reflector lamps is wide enough so that even when used in auxiliary reflectors or shields the vertical illumination is higher than with most luminaires, yet the overall cost of light is low as compared to luminaires because of the high maintenance factor. If the experience obtained with the incandescent R-52 lamps is representative of the importance attached by most users to the importance of a high maintenance factor, the R-52 reflector mercury should have very rapid acceptance.

*Authors: General Electric Co., Nela Park, Cleveland, Ohio.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Council Action Taken at New York Meeting

The second meeting of the 1952-1953 Council of I.E.S. was held December 11, 1952 at the Hotel Lexington, New York City. Present were: Prof. E. M. Strong, President, presiding, and Past Presidents S. G. Hibben and Walter Sturrock; Vice-Presidents Duncan M. Jones and A. H. Manwaring; General Secretary C. C. Keller; Treasurer Kirk M. Reid; Directors G. W. Beals, J. S. Schuchert, J. F. Whitehead, Jr., F. C. Winkler, and E. H. Salter proxy for Roy A. Palmer; Regional Vice-Presidents F. P. Labey, Paul H. Hildebrand, L. C. Twichell, L. B. Paist, George J. Taylor, and M. N. Waterman proxy for R. Cecil Paslay, and N. Macdonald proxy for L. A. Hobbs; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; C. E. Ellis, Advertising and Promotion Manager; and H. R. Finney, L. S. Cooke, C. H. Goddard and R. G. Slauer.

Before proceeding with the meeting's agenda, Council rose for a moment's silence in respect to the memory of Samuel E. Doane, President of I.E.S. in 1919-1920, who died December 10 at the age of 82. Action was taken to authorize the preparation of an appropriate Resolution of the Society's loss.

Publications

Duncan M. Jones, Vice-President, reported on the Society's publication program. Noting that a meeting of the Publications Committee was held December 10, he told Council of the educational program underway to familiarize local membership with the availability of I.E.S. publications. A number of display cases are being built for use at Regional and local meetings, displaying various publications.

Mr. Jones reported the 1952 *I.E.S. Lighting Handbook* was approaching complete sell out, and indicated a reprinting may be required in late spring.

New Elections

The Board of Examiners, Eugene Fahey, Chairman, recommended for election four new members and three reinstatements, and the transfer from Associate to Full Member of seven Associate Members. Council acted favorably on these elections. For Council's information, the Board of Examiners reported their election of 124 Associate Members and 59 Student Members. A list of all these elections appears elsewhere in the Telecast Section, this issue.

Following action taken as reported, the current membership totals are as shown in the following tabulation:

September 30, 1952		December 11, 1952
7394	Total Membership	7582
34	Members Emeritus	33*
41	Fellows	55
1797	Members	1824
5293	Associate Members	5386
229	Student Members	284

*Includes 11 Fellows.

Local Activities

Reporting for Society activities in Sections, Chapters and Regions, Duncan M. Jones, Chairman, noted the increased responsibility assumed by the office of Regional Vice-President. In this connection, it was suggested that "training meetings" be held annually for Regional V-Ps, who in turn would call local meetings to indoctrinate Section and Chapter chairmen in successful procedure.

Mr. Jones reported regional nomination committees were well organized and that the I.E.S. sponsored contest for "My Most Interesting Lighting Job" was a major project for most Sections and Chapters this year.

New Sustaining Members

A report given for C. C. Shotwell, Chairman of the Sustaining Member Committee, recommended the election of two new Sustaining Members, as follows:

Major Equipment Company Inc.
4603-19 Fullerton Ave.
Chicago, Ill.
Official Representative—Ross O. Major

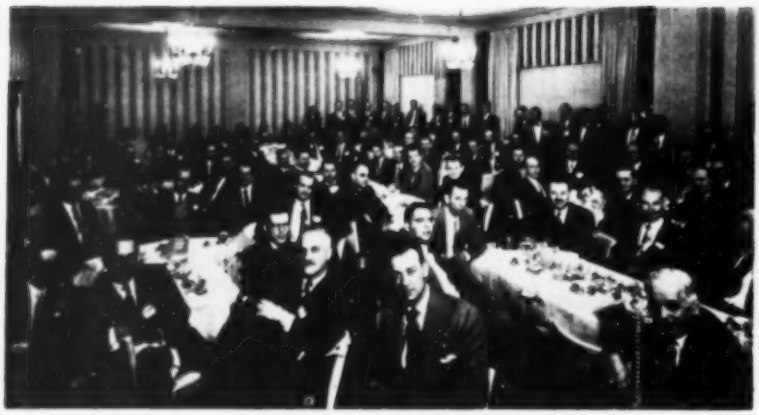
Shalda Manufacturing Co. Inc.
835 S. Fernando Blvd.
Burbank, Calif.
Official Representative—William Shalda

Technical Program

The Society's current activities in its technical work was reported to Council by A. H. Manwaring, Vice-President, and C. L. Crouch, Technical Director. A high spot in this activity during the past

AT COUNCIL Meeting December 11, among those present were, left to right around table: F. P. Labey, L. B. Paist, Walter Sturrock, F. C. Winkler, D. M. Jones, G. J. Taylor, K. M. Reid, Ruby Redford, Pres. E. M. Strong, S. G. Hibben, A. D. Hinckley, J. F. Whitehead, G. W. Beals, J. S. Schuchert, P. H. Hildebrand, L. C. Twichell, H. R. Finney.

Here and There with I.E.S. Members



St. Louis Section attendance grows with every meeting. Some 103 people attended the dinner meeting shown, November 13, an attendance figure fast becoming "average" for this Section's gatherings. Guest speaker was C. C. Keller, I.E.S. General Secretary, who spoke on Society activities and gave an illustrated talk on lens lighting.

Holding the Charter of the new Central Illinois Chapter are: front, L. B. Paist, Regional V-P; R. H. Rahe, Chapter Chairman; rear, W. A. Weibel and E. H. Buehler, Vice-Chairman.

At the Charter presentation of the new Student Branch at the Southern College of Optometry, November 25, are: seated, Joseph Schandler, Secretary-Treasurer; J. L. Levelsmier, Chairman; D. E. David, Vice-Chairman. Standing are R. R. Semple and R. K. Harpe, Jr., members of the Board of Governors; Dr. O. N. Cole, Faculty Advisor, and Regional V-P R. C. Paslay, Southern Region.

Trying out illumination and brightness instruments at the Measurement Clinic held in Buffalo, November 19, as part of the Technical Committee Forum Program are: seated, William Powell; standing left to right around table, D. L. Williams, C. L. Crouch, A. A. Brainerd, Roy Jones and Norman Kridel. Photo courtesy of Bob Blatt, *Electrical World*.

A total of 179 attended the November 24 meeting of the Quebec Chapter, I.E.S., when Ewart M. Haacke of the Montreal Section was guest speaker. Mr. Haacke's subject was "l'Eclairage commercial moderne" and his presentation was given partly in French.

month was the two-day Technical Committee Forum held in Buffalo November 20 and 21, and reported elsewhere in this issue.

Mr. Crouch reported a number of technical committee reports nearing completion, with other projects under way.

I.E.S. Membership Booklet Available from Headquarters

A pocket sized accordian folded booklet setting forth the benefits and requirements of membership in the Society has been prepared by the Membership Committee and is available to Section and Chapter Membership Chairmen as a "reminder" for wavering members and an explanation of the I.E.S. organization for prospective members. The booklet summarizes briefly the national and local activities and outlines the Society's services. It is available from the General Office, Society headquarters.

Rutgers University Sponsors Occupational Vision Conference

The second Conference on Occupational Vision, sponsored annually by Rutgers University (New Jersey) was held November 13 and 14 at the Hotel Dennis, Atlantic City. The exceptionally constructive program included lectures by a number of I.E.S. members, and a special Forum on Aids for Better Seeing.

Presiding Chairman for the Forum for the Illuminating Engineering Society was Arthur L. Talbot, of Public Service Electric and Gas Co., Trenton, N. J.

Objectives of the annual conference are education in conservation of vision, protection of eyes against injury, and aiding in increasing the efficiency, health and welfare of industrial workers. Speakers at the two-day meeting represent leaders in various fields, to bring together knowledge from the several groups, each relating to industrial vision.

The five sessions of the conference included:

Opening of the Conference—Professor Maurice A. Chaffee, Director, University Extension Division, Rutgers University.

Forum on Visual Efficiency and Production. Presiding: Lowell F. Johnson, Assistant to Vice-President, American Home Products Corporation.

Efficient Vision as a Productive Tool. R. Foster Ash, O.D., Visual Consultant, International Business Machines, Inc., Binghamton, N. Y.

Savings in Production with a Sound Vision Program, Dorothy Brinkley, R.N., Motorola, Incorporated, Chicago, Ill.

Setting Up and Organizing an Occupational Vision Testing Program. G. Luther Weibel, Personnel Director, Magnet Mills, Incorporated, Clinton, Tennessee.

Forum on Eye Safety.
Presiding: William Shields, Supervisor of Safety, Calco Chemical Division, American Cyanamid Co., Bound Brook, N. J.

Eye Protection Practices in Heavy Industries, Gerard O. Griffin, Director of Safety, Dravo Corporation, Pittsburgh, Penna.

Eye Protection Pracices in Light Industries, Dan McKeen, Safety Engineer, Panelyte Division, St. Regis Paper Company, Trenton, N. J.

Tour of Educational Display Exhibits.

Forum on Conservation of Vision.
Presiding: Irvin Levy, M.D., F.A.C.S., F.I.C.S., Wills Eye Hospital.

Eye Injuries and Their Emergency Care, Carroll R. Mullen, M.D., Executive Surgeon, Wills Eye Hospital, Philadelphia, Penna.

Incidence of Glaucoma Among Industrial Workers, Conrad Berens, M.D., Executive Eye Surgeon, New York Eye and Ear Infirmary.

Banquet — Hotel Dennis.
Speaker: Dr. Charles F. McCuen, Executive Vice-President and Director of Research, General Motors Corporation, Detroit, Mich.
Toastmaster: Ernest E. McMahon, Dean, University Extension and University College, Rutgers University.
Remarks: Dr. Mason Gross, Provost, Rutgers University.

Forum on Aids for Better Seeing.
Presiding: Arthur L. Talbot, Illuminating Engineering Society.

LIGHTING CALENDAR

Society Events

February 12, 1953—Meeting of I.E.S. Council, New York, N. Y.

March 23-24, 1953—Canadian Regional Conference, Chateau Laurier, Ottawa, Ont.

April 9-10, 1953—South Pacific Coast Regional Conference, Los Angeles, Calif.

April 12-14, 1953 — Southwestern Regional Conference, Hotel Baker, Dallas, Texas.

April 23-24, 1953—Pacific Northwest Regional Conference, Multonomah Hotel, Portland, Ore.

April 30 - May 1, 1953 — Midwestern Regional Conference, Hotel Radisson, Minneapolis, Minn.

May 14-15, 1953 — East Central Regional Conference, Hotel Lord Baltimore, Baltimore, Md.

May 18-19, 1953 — Southern Regional Conference, Sedgefield Inn, Greensboro, N. C.

May 25-26, 1953 — Great Lakes Regional Conference, Syracuse Hotel, Syracuse, N. Y.

September 14-18, 1953 — Illuminating Engineering Society, National Technical Conference, Commodore Hotel, New York, N. Y.

Industry Events

January 19-22, 1953 — Plant Maintenance Show, Public Auditorium, Cleveland, Ohio.

January 19-23, 1953 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

January 26-29, 1953—American Society of Heating and Ventilating Engineers, 59th Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

March 9-12, 1953 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

March 30 - April 2, 1953 — Annual Sales Conference, Edison Electric Institute, Edgewater Beach Hotel, Chicago, Ill.

April 27 - May 1, 1953 — Society of Motion Picture and Television Engineers, Hotel Statler, Los Angeles, Calif. Semi-Annual Convention.

April 28-30, 1953 — The American Society of Mechanical Engineers (Spring Meeting), Deshler-Wallick Hotel, Columbus, Ohio.

May 18-22, 1953 — National Materials Handling Exposition, Convention Hall, Philadelphia, Pa.

May 24-28, 1953 — National Association of Electrical Distributors, 45th Annual Convention, Conrad Hilton Hotel, Chicago, Ill.

June 1-4, 1953 — 21st Annual Convention, Edison Electric Institute, Atlantic City, N. J.

June 9-12, 1953 — Store Modernization Show, Madison Square Garden, New York, N. Y.

June 28 - July 2, 1953 — American Society of Mechanical Engineers, Semi-Annual Meeting, Statler Hotel, Los Angeles, Calif.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953 — Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953 — 25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

September 23-25, 1953 — Annual Meeting, Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont.

October 5-9, 1953 — Society of Motion Picture and Television Engineers, Hotel Statler, New York, N. Y. Semi-Annual Convention.

October 19-23, 1953 — 41st National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 9-13, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 29 - December 4, 1953 — The American Society of Mechanical Engineers (Annual Meeting), Statler Hotel, New York, N. Y.

January 18-22, 1954 — Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 8-11, 1954 — National Electrical Manufacturers Association, Edgewatar Beach Hotel, Chicago, Ill.

Optical Aids for Better Seeing, F. Gordon Foster, Bell Telephone Laboratories, Murray Hill, N. J.

Modern Use of Paint as an Aid to Safety and Efficiency, S. W. Quisenberry, National Manager Maintenance Sales, E. I. duPont de Nemours and Company, Wilmington, Del.

Studies in the Physiological Cost of Seeing, Willard Allphin, Illumination Research, Sylvania Electric Products, Inc., Salem, Mass.

Modern Use of Light as a Production Tool (Illustrated by Practical Applications), Robert L. Zahour, Manager, Illuminating Engineering Section, Westinghouse Electric Corporation, Bloomfield, N. J.

J. J. Neidhart, Application Engineer, Westinghouse Lighting Division, Cleveland, Ohio.

Forum on Economic Aspects of Occupational Vision.

Presiding: Arthur R. Neale, Jr., O.D., F.A.A.O.

The Eye Man's Relationship to the Economics of Industry's Visual Problems, R. E. Wagenhals, Director of Quality Control, Timken Roller Bearing Company, Canton, Ohio.

Economic Value of Vision, William H. Seymour, Vice-President, Liberty Mutual Insurance Company, Boston, Mass.

Economics of Visual Care, Roy F. Marks, Director of Ophthalmic Distribution, Bausch & Lomb Optical Co., Rochester, New York.

Educational displays in the hotel lobby showed the latest devices for vision screening, eye protection, conservation measures, industrial application of optics and visual efficiency practices and procedures.

General Chairman of the Conference was Dr. John R. Wittekind, New Jersey Optometric Association.

I.E.S. Technical Committee Chairmen Hold Two-Day Forum in Buffalo

Thirty four of the Society's technical committees were represented at the highly valuable two day Technical Committee Forum held November 20 and 21 at the Hotel Statler, Buffalo, New York. A. H. Manwaring, Senior Vice-President of I.E.S., was chairman of the conference.

Now in its third year, this annual conference of technical committee chairmen is fast becoming one of the Society's most important meetings. The 34 chairmen present had an opportunity to correlate their own committee activities with those of other technical committees, review the status of current projects, and — not so concrete but of immense importance in I.E.S. work — get the "feel" of the overall objectives of the Society's technical program. At round table discussions both days, progress reports were given for the committees represented, a feature of special value in orienting new chairmen.

The Visual Task Evaluation Clinic held in connection with the conference was a most unusual and instructive feature. Procedures for the practical use of various illumination and brightness instruments were demonstrated, and their characteristics described. Following the demonstrations, a "practice session" was held, during which all those attending had an opportunity to operate the meters on sample tasks such as metal work, small steel scales, sewing with various degrees of contrast of thread against background, pencil writing, and even detecting a hair in a dish of Jello.

The Luckiesh-Moss Visibility Meter and the Luckiesh-Taylor Brightness Meter were demonstrated by Sylvester K. Guth, Director of the Research Laboratory, General Electric, Nela Park. Professor C. L. Cottrell of Cornell University demonstrated the Cottrell Contrast Brightness Threshold Meter. The Macbeth Illuminometer was demonstrated by J. F. Parsons, Niagara Mohawk Power Corp. A new Photoelectric Brightness Meter, soon to be available for illumination work, was shown by its inventor, Dr. Karl Freund of the Photo Research Corp., who flew in from the coast specially for the meeting.

The group got together for dinner November 20, for an informal dinner party, after which they were entertained by Mr. Manwaring with "Footloose in Toulouse," colored slides taken during his trip to France last summer.

Committees represented at the Forum were:

Store Lighting — R. C. Allison, T. Eaton Co. Ltd., Toronto, Ont.

Aviation — R. C. Blatt, McGraw-Hill, New York, N. Y.

Lighting Study Projects in Industry and Central Station Properties — A. A. Brainerd, Philadelphia Electric Co., Philadelphia, Pa.

Technical Committee Forum and Industrial — Willard Brown, General Electric Co., Cleveland, Ohio.

Technical Committee Forum — Robert Burnham (proxy for A. F. Wakefield), F. W. Wakefield Brass Co., Vermilion, Ohio.

Sports Lighting — A. H. Clarke, Crouse-Hinds Co., Syracuse, N. Y.

School Lighting — J. M. Chorlton, Board of Education, Toronto, Ont.

Light Sources — George S. Evans, Westinghouse Electric Corp., Detroit, Mich.

Civil Defense — J. C. Forbes, General Electric Co., Cleveland, Ohio.

Standards of Quality and Quantity — S. K. Guth, General Electric Co., Cleveland, Ohio.

TECHNICAL Committee Forum met in Buffalo, November 20-21, with 34 of the Society's technical committees represented. A. H. Manwaring (right—standing), I.E.S. Vice-President, was chairman of the two-day conference.

VISUAL Task Evaluation Clinic at Technical Committee Forum in Buffalo November 20-21, afforded opportunity to practice with various brightness and illumination instruments. Shown are (l. to r.) Chas. Justice, S. K. Guth, A. H. Manwaring, E. M. Strong and C. L. Cottrell.

Testing Procedures — G. A. Horton, Westinghouse Electric Corp., Cleveland, Ohio.
Lighting Design Practice — J. Roy Jones, Westinghouse Electric Corp., Bloomfield, N. J.
Clothing Industry Sub-Committee — N. T. Kridel, Rochester Gas & Electric Co., Rochester, N. Y.
Technical Committee Forum — W. P. Lowell, Jr., Sylvania Electric Products Inc., Salem, Mass.
Lighting Education — H. H. Magdsick, General Electric Co., Cleveland, Ohio.
Chairman, Technical Committee Forum — A. H. Manwaring, Philadelphia Electric & Mfg. Co., Philadelphia, Pa.
Brightness Measurements — Sub-Committee of Testing Procedures Committee — J. H. McCulloch, General Electric Co., Fort Wayne, Indiana.
Daylighting Availability Sub-Committee — R. W. McKinley, Pittsburgh Corning Corp., Pittsburgh, Pa.
Daylighting — R. W. McKinley (proxy for R. Miller), Pittsburgh Corning Corp., Pittsburgh, Pa.
Color and Illumination — J. A. Meacham, Sherwin-Williams Co., Cleveland, Ohio.
Office Lighting — J. J. Neidhart, Westinghouse Electric Corp., Cleveland, Ohio.
I.E.S.-U. S. Public Health Service Joint Committee — J. Parsons, Niagara Mohawk Power Corp., Buffalo, N. Y.
Auditoriums and Churches — Edward Rambusch, Rambusch Decorating Co., New York, N. Y.
Visual Problems in Schools, Sub-Committee — Paul Seagers, School of Education, Indiana University, Bloomington, Indiana.
President, Illuminating Engineering Society — E. M. Strong, Cornell University, Ithaca, N. Y.
Buses, Trolley, Railroad Cars — J. L. Swarner, Pullman Std. Car Mfg. Co., Chicago, Ill.
Illumination Performance Recommendations — R. P. Teele, National Bureau of Standards, Washington, D. C.
Reflected Glare — G. P. Wakefield, F. W. Wakefield Brass Co., Vermilion, Ohio.
Residence Lighting — Mary Webber, General Electric Company, Cleveland, Ohio.
Light Control and Equipment Design — David L. Williams, Westinghouse Electric Corp., Bloomfield, N. J.
Street Lighting — F. D. Wyatt, Chicago Park District, Chicago, Ill.
Technical Committee Forum — I. A. Yost, Westinghouse Electric Corp., Cleveland, Ohio.
Protective Lighting—Maintenance and Hospital — Mary Webber (proxy for Howard Haynes), General Electric Co., Cleveland, Ohio.

Also present at the conference were:

R. A. Boyd, guest, University of Michigan, Ann Arbor, Michigan.
C. L. Cottrell, guest, School of Electrical Engineering, Cornell University, Ithaca, N. Y.
Charles Justice, guest, Philadelphia Electric & Mfg. Co., Philadelphia, Pa.
C. L. Crouch, Technical Director, I.E.S.
Ruby Redford, Editor, I.E.S.
Eve Freyer, Technical Assistant, I.E.S.

A.A.A.S. Annual Meeting Held in St. Louis

The 119th Annual Meeting of the American Association for the Advancement of Science was held in St. Louis, December 26-31, officially recognized as the final event of the Centennial of Engineering. The general topic for the meeting was "The Contribution of Science and Mathematics to Engineering and Industry."

SAN JOSE Chapter receives formal Charter at meeting Nov. 19. William Addison (right), Chairman of the new Section, accepts Charter from Carl O. Martin of Northern California Section. Witnessing the ceremony are L. A. Hobbs (left), Regional V-P and Walter E. Nordby, Vice-Chairman of San Jose Chapter.

San Jose Chapter Holds Charter Meeting

A number of Western members helped inaugurate a new I.E.S. Chapter, when the San Jose Chapter (San Jose, California) held its Charter meeting there on November 19. A dinner meeting at the Hawaiian Gardens, San Jose, celebrated the affair.

Highlight for the 40 members and guests present was the Charter presentation, made by Carl O. Martin, former South Pacific Coast Regional V-P, and the address on Society Aims by L. A. Hobbs, current Regional V-P. Walter Addison, the new Chapter's chairman accepted the Charter and official gavel for his Chapter.

Program Chairman Walter Nordby presided at the meeting and introduced the speakers.

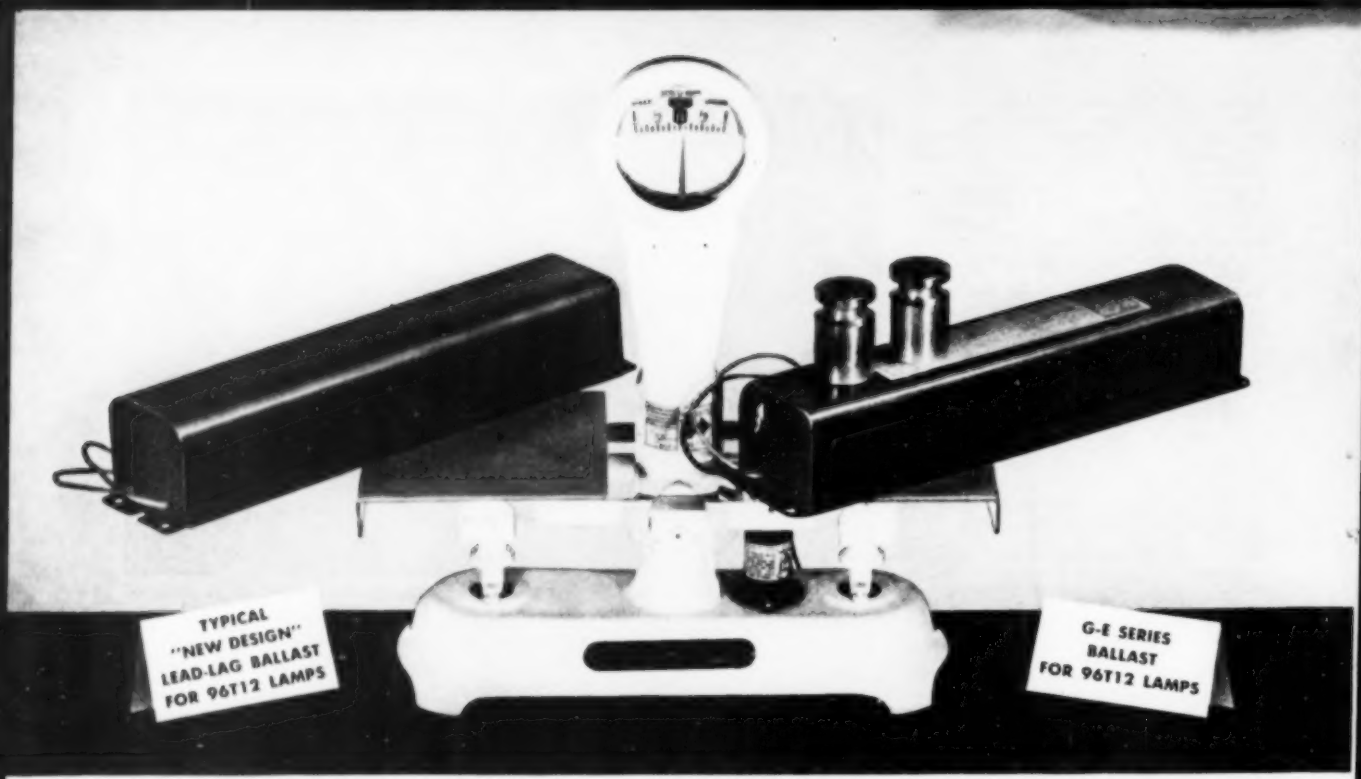
Guests attending the inaugural meeting included in addition to Mr. Hobbs and Mr. Martin, a number of Northern California Section members, headed by that Section's chairman, Robert Thunen.

Mid-South Chapter, I.E.S. Celebrates Inaugural

Inaugural ceremonies for the newly elected Mid-South Chapter of I.E.S. (Memphis, Tennessee) were held at a dinner meeting at the King Cotton Hotel there November 25. R. C. Paslay, Southern Regional V-P, formally presented the new Chapter's Charter. John

(Continued on page 12A)

CHARTER Night of the new Mid-South Chapter was held at the King Cotton Hotel in Memphis. At the head table across the rear of photo are left to right: Mrs. M. E. Broom; Dr. M. E. Broom, Chairman of the Chapter; F. M. Neill, Secretary-Treasurer; R. C. Paslay, V-P of the Southern Region; Mrs. F. M. Niell, John Gilchrist and W. A. Munding.



G-E SERIES BALLAST WEIGHS LESS than lead-lag ballast of comparable quality, for 96T12 lamps. Above, G-E ballast is two pounds lighter than typical lead-lag ballast. Series design requires fewer materials, gives lower weight, cost, at no reduction in quality.

Series or lead-lag ballasts for

G-E Series Ballast for 96T12 lamps costs less, weighs less, has lower power losses than lead-lag ballasts of same quality; also gives equal lamp life with little difference in "strobe"

Both G-E series ballasts and so-called "new design" lead-lag ballasts for 96T12 lamps assure full rated lamp life, have comparable lamp replacement costs, and *provide approximately the same stroboscopic correction.*

For 96T12 lighting applications, the G-E series ballast will use less materials and will weigh less; will have lower losses and lower power consumption; and will provide lower cost lighting than a lead-lag ballast of comparable quality.

The reason is simple. The series ballast more efficiently starts and operates the lamps because they are started in sequence rather than simultaneously. Therefore, fewer materials are needed, and a lighter, less costly ballast results.

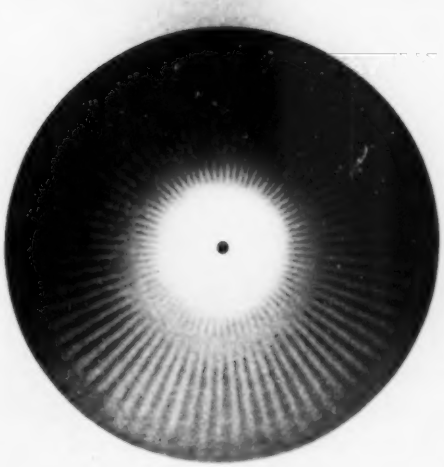
If a lead-lag ballast approaches a series ballast in active material utilization as well as weight, it must almost certainly give poorer lamp performance. Why? Because such reductions are made at the cost of lamp current, giving less light per fixture. This means that more fixtures would be necessary to achieve the same total light level.

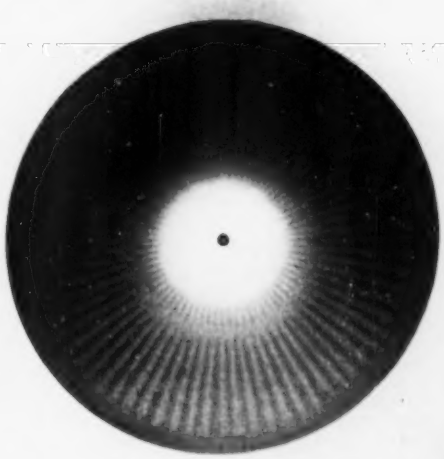
A MATTER OF ECONOMICS

General Electric makes more ballasts of all types, including those with lead-lag circuits, than any other manufacturer. G-E research engineers consider every important factor for each type of ballast. In ballast design, other things being equal, the biggest single factor is highest practical quality at lowest cost. That's why General Electric recommends series instead of lead-lag ballast for 96T12 lamps.

GET FULL INFORMATION **—complete details on comparisons between series and lead-lag ballasts for 96T12 lamps are in bulletin GEA-5909. Write Section C 412-103, General Electric Company, Schenectady 5, New York.**

GENERAL ELECTRIC

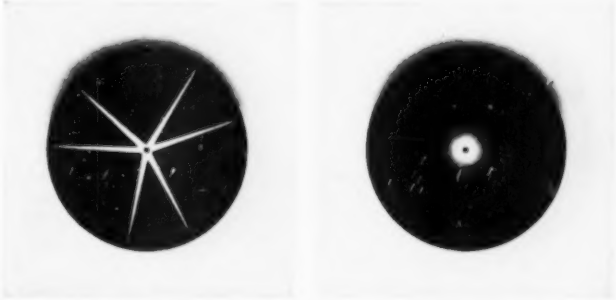




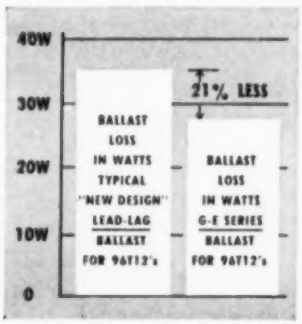
NO APPRECIABLE "STROBE" DIFFERENCE with either G-E series ballast (left) or "new design" lead-lag ballast (right). Both pictures were taken under identical conditions: disc spinning at exactly 100 rpm, illuminated by same two 96T12 lamps.

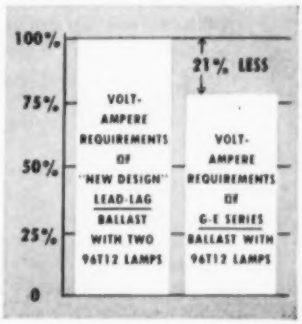
96T12 lamps? Here are the facts:

EQUAL MAINTENANCE TIME is taken in replacing lamps, whether series or lead-lag ballast is used. Time is spent in moving ladder and climbing up, not in few seconds taken to change lamps.



STATIONARY "STROBE" DISC, left, for testing 96T12 lamps is black with white lines, mounted on 100 rpm motor. Right: disc spinning at 100 rpm in daylight shows no lines — or zero "strobe."





LESS POWER CONSUMPTION, inherent to G-E series ballast, is shown in left chart, above. Right: series ballast must be smaller, lighter, as weight and size are about proportional to volt-amperes.

(Continued from page 9A)

Gilchrist, serving as proxy for San Jose Chapter, presented the official gavel, a gift from "next youngest" San Jose. The gavel was accompanied by a scroll signed by the officers and members of the Board of Managers of San Jose Chapter.

While the Charter meeting celebrated the first official meeting as an I.E.S. Chapter for the Mid-South group, it was by no means the first lighting meeting enjoyed by these members. The Mid-South Chapter of I.E.S. developed from an especially active group of lighting people in Memphis who have been organized for a number of years as "the Mid-South Illumination Club." Under I.E.S. auspices, they expect to expand still further the fine work they have carried on in illumination in their area.

The Charter meeting was attended by 80 members and guests. In addition to the Charter presentation, the program included a lecture on home lighting by William Schoenherr and a showing of the home lighting film, "Bright Future," a subject chosen for its interest to the ladies present as well as the members. Dr. Bert O. Miller of Little Rock, Arkansas, was honored as the member traveling the greatest distance to attend the meeting.

HEAD TABLE at the Charter ceremony of the Central Illinois Chapter, Peoria, held October 24 with 101 attending. Officers of the parent Chicago Section and Regional V-P L. B. Paist were guests of honor.

Central Illinois Chapter Holds Charter Meeting

A grand total of 101 members and guests attended the Charter meeting of the new Central Illinois Chapter of I.E.S., October 21, at the Jefferson Hotel, Peoria, Ill.

The charter was presented to the new Chapter by L. B. Paist, Regional V-P of the Midwest Region. Mr. Paist addressed the group on the functions of I.E.S. and their part in Society affairs. R. H. Rahe, first chairman of the Chapter, received his gavel of office from C. B. Pederson, past chairman of the Chicago Section, who was most instrumental in the development of the new Chapter.

The Central Illinois Chapter had its beginnings back before World War II, when a group of men in the area, interested in the advancement of knowledge of illumination, banded together and under the guiding hand of the Central Illinois Light Co. formed the Central Illinois Lighting Association. During the war and for several years after it, this group continued as an independent society, meeting occasionally to discuss lighting and problems in illumination. Then in the spring of 1951, the group felt ready to enter into I.E.S. functions. With the help of C. B. Pederson, then chairman of the Chicago Section, and other Section members, the Central Illinois Lighting Study Club of the I.E.S. Chicago Section was formed, with E. H. Davis as president.

Finally, in April of 1952, the goal of Chapter status was reached, officers were elected and the new Chapter was on its way with a local membership of 43.

Problems of Electrical Industry To Highlight Plant Maintenance Conference

In recognition of skyrocketing costs of maintenance in the electrical manufacturing industry and the added engineering and personnel problems due to increasing mechanization, it was decided to set aside two sessions of the current Plant Maintenance Conference exclusively to a discussion of problems peculiar to electrical manufacturing plants.

In addition to these special sessions devoted to maintenance problems of the electrical manufacturing plants, three other meetings are of particular interest for the electrical industry. These include a roundtable on problems of lighting maintenance in all plants, and sectional conferences on maintenance of electrical equipment and maintenance of power plant equipment. Willard C. Brown, manager of the Appliance Engineering Division of General Electric Co., Nela Park, is discussion leader for the Lighting Panel, Tuesday, January 20.

The conference takes place at the Public Auditorium, Cleveland, January 19-22, inclusive, concurrently with the Plant Maintenance Show, where thousands of machines and products used in maintenance are exhibited.

The sessions devoted to the electrical manufacturing industry as well as lighting maintenance will be roundtable discussions and each will be conducted by a chairman and a discussion leader. These two will be held simultaneously. The first session will take place Tuesday, Jan. 20, from 2 to 4:30 p.m., and the second at the same time the next day. Those attending the first session will be encouraged to submit questions for answer at the second meeting. Industry leaders from all parts of the country are expected to attend.

The conference on maintenance of electrical equipment and maintenance of power plants also will be conducted simultaneously but these will take place Monday, Jan. 19, from 8 to 10 p.m.

In addition to these six sessions devoted principally to the needs of the electrical industry, there will be 60 other meetings dealing with general aspects of plant maintenance.

Safe Lamp Disposal System Used at Naval Shipyard

Danger from broken glass has been minimized at the Pearl Harbor Naval Shipyard in the new method of disposal of fluorescent lamps. A powered lamp breaker has been developed which is fitted with a conical base by which refuse can be funneled into a steel drum. Weights swinging from a fan motor driven shaft

Smithcraft AREA ILLUMINATION-

CHALLENGE

TO THE LIGHTING INDUSTRY

A challenge to create new and striking lighting effects . . . a challenge to increase lighting levels materially with accompanying comfort . . . a challenge to use Smithcraft Area Illumination to implement your own lighting ideas.

Smithcraft Area Illumination brings to overall lighting a brand new structural simplicity that eliminates previous mechanical difficulties of installation and servicing. This system is actually one lighting "fixture" of limitless dimensions. There is no multiplicity of supports to the ceiling or complicated electrical service connections to clutter the plenum and interfere with other services.

With Smithcraft Area Illumination, the architect and engineer have an unrestricted freedom of choice as to size, pattern, shielding, intensity and periphery . . . and it's economical efficient extremely easy to install.

After thorough investigation of all available overall lighting, Smithcraft Area Illumination has been chosen by America's leading companies for today and tomorrow's finest lighting installations.

freedom of SIZE
freedom of PATTERN
freedom of INTENSITY
freedom of SHIELDING
freedom of PERIPHERY

Write for further information on Smithcraft Area Illumination

Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

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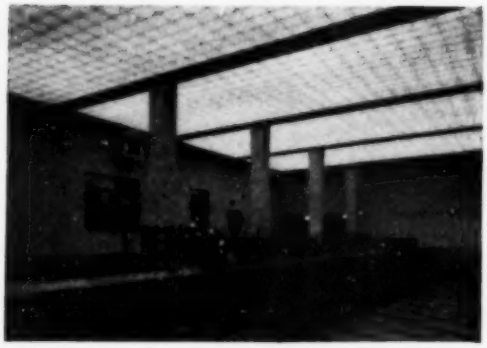
"LUVE-TILE"

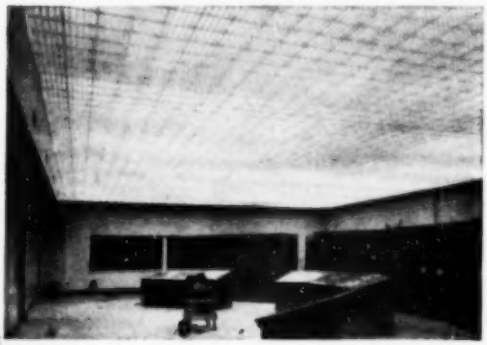
This latest development in modern interior lighting is a boon to contractors because . . .

- It is extremely simple to calculate the amount required for the installation.
- There are only four basic elements to use! A modular 12" square of rigidly molded polystyrene louvre, a clip, a hanger and a strap.
- There are no complicated T-bars necessary to support "Luve-Tile".
- "Luve-Tile" always aligns perfectly and pleases customers with its symmetry.
- "Luve-Tile" is scientifically designed and is correct from an efficiency and brightness viewpoint.
- When the installation is complete, it is very simple to maintain—an important factor in customer approval.

For complete information on "Luve-Tile" write for Catalog, Section Z8.

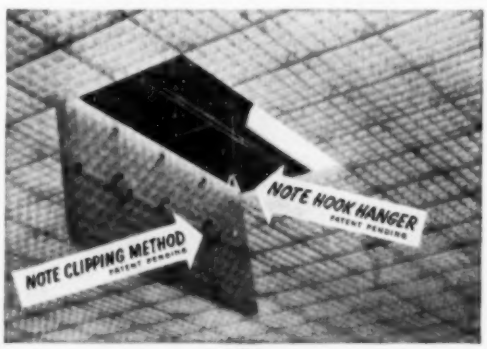


● Illustration shows a modern bank installation, where "Luve-tile" helped to achieve an air of efficiency.



● In this power control room, "Luve-tile" has successfully cut down glare and eyestrain.

● "Luve-tile" was a major factor in achieving the modern appearance of this retail store.



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ANOTHER WILSON FIRST

pulverize the lamps as they are pushed into the breaker, and four sprinkler nozzles settle phosphorus particles and flush them into the drum. About 230 4 foot lamps can be broken into one 55-gallon drum, after which it is sealed and buried. The tube breaker is self-cleaning, reducing any chance of cuts and scratches.

U. S. Committee of C.I.E. Holds Annual Meeting

The United States National Committee of the Commission Internationale de l'Eclairage held its annual meeting November 18 and 19, 1952, at the Strath Haven Inn, Swarthmore, Pa., with 45 members and visitors attending. The present officers were re-elected for the coming year, as follows:

President ..... Arthur A. Brainerd
Vice-President ..... Willard C. Brown
Secretary ..... Louis E. Barbrow
Treasurer ..... Theodore D. Wakefield

Important discussions included a review of the work of the international committee, on which the United States is represented by H. H. Magdsick, which has been engaged in a general reorganization of technical activities. During the Swarthmore conference, personnel for the Secretariats assigned to the United States and U. S. representation on 35 technical committees was discussed. The U. S. has been assigned Secretariats covering the subjects of Colorimetry; Colors of Signal Lighting; Operating Accessories; Pre-Determination of Illumination; Lighting for Photography, Cinema and Television; Airborne Lighting and Signals; and Popular Education.

Reports presented during the two-day conference included the U. S. Committee's work on Automobile Lighting, presented for V. J. Roper by Willard C. Brown; Aviation Ground Lighting and Colors of Signal Lights by F. C. Breckenridge; and Colorimetry by Dr. D. B. Judd. Mr. Nagel of Wright Field, discussed the present status of tables and graphs on Planckian Constants. Reports on the French I.E.S. convention in Toulouse were given by M. N. Waterman and A. H. Manwaring, who attended that meeting as scheduled speakers.

A dinner meeting was held November 18 in connection with the conference. Speakers at the dinner were: Dr. Ward Harrison, President of C.I.E., who spoke on the current status of affairs in the C.I.E., from a world viewpoint; J. Frank Gaskill, General Sales Manager, and George E. Whitwell, Vice-President in Charge of Sales of the Philadelphia Electric Co., who addressed the group on the impact of research and study on the lighting industry.

UNITED STATES National Committee of C.I.E. met for two-day conference November 18 and 19 at Swarthmore, Pa. Shown are 45 members and visitors who attended the dinner at Strath Haven Inn.

Street Lighting Course Added To New England Section Curricula

In addition to the annual Fundamentals of Illumination Course, last Fall the New England Section, I.E.S. co sponsored a program on Fundamentals of Street Lighting, in cooperation with the Electric Institute of Boston's Lighting Bureau. The enrollment of 110 gives an indication of the enthusiastic response to the new course. The program, conducted by the Section's Education Committee, comprised six two-hour sessions, with the following topics and speakers. Program Chairman was W. B. Kennedy, Sylvania Electric Products, Inc.

The What and Why of Good Street Lighting — E. B. Karns, Westinghouse Electric Corp.
Fundamentals of Street Lighting — S. R. Williams, Holophane Co., Inc.
Layout Principles — R. M. Swetland, General Electric Co.
Special Situations in Street Lighting — R. G. Slauer, Sylvania Electric Products, Inc.
Available Equipment — J. W. Young, New England Electric System.
Standardization in Street Lighting — W. H. Edman, Line Material Co., Chairman, N.E.M.A.-E.E.I. Standardization Committee.

The annual Fundamentals of Illumination course this year attracted about 50 enrollees. It was presented in seven two-hour sessions covering theory, calculations and applications. Program Chairman was John W. Young, New England Electric System.

The program and speakers were as follows:

PART of the large group of New England engineers who attended the Street Lighting Fundamentals Course sponsored by the New England Section, I.E.S. in cooperation with the Electrical Institute of Boston's Lighting Bureau.

Theories of Light and the Eye—R. B. Brown, Jr., Boston Edison Co.
Lighting Terms, Control and Measurement—Norman Falk, Holophane Co., Inc.
Light Sources—Incandescent—W. B. Kennedy, Sylvania Electric Products, Inc.
Light Sources—Fluorescent—G. A. Meyers, Sylvania Electric Products, Inc.
Color, Light and Paint—E. B. Nelson, U. S. Gutta Percha Paint Co.
Illumination Design—L. E. Duval, Jr., Day-Brite Lighting Inc.
Economics of Lighting—F. J. Vorlander, Champion Lamp Works.
Exterior Lighting Applications—J. S. Lindsay, General Electric Co.
Interior Lighting Applications—H. A. Klopot, Henry A. Klopot, Lighting.

Both courses were held at the Hotel Touraine in Boston. Tuition fee for both was $2.00 to I.E.S. Members and $4.00 to non-members.

Atlanta Residence Lighting Forum Plans Active Year

The Atlanta Residence Lighting Forum, sponsored by the Georgia Section, I.E.S., held its first meeting of the 1952-53 year November 3, with an attendance of 68. Miss Nina Faye Bonner, chairman, presided, and the program was introduced by Mrs. Fred Wenn, program chairman.

Guest speaker was Miss Edith Buchholtz, Residential Lighting Consultant, Westinghouse Lamp Division, who gave an illustrated lecture featuring unusual residential applications.

Programs for the coming year were previewed. The December meeting featured "Christmas Lighting—Indoors and Out." The January meeting is to be a repeat of last year's popular "What's New" program, with all members submitting ideas for presentation. A tour is being planned for one of the spring meetings, which will include visits to new homes with built in lighting as well as to some gardens which are lighted as a result of the Garden Lighting project arranged by the Forum last spring.

Chicago Section Tours Optometry College

The Chicago Section, I.E.S., held its December 4 meeting at Northern Illinois College of Optometry, Chicago. The meeting, which was attended by 74 society members and College personnel, was preceded by a dinner served in the College dining room.

Introductory remarks by Carl Zerse, Director of the Chicago Lighting Institute, were followed by a two-hour program of brief addresses by the College faculty. Dr. Richard Feinberg, President of the College, spoke on "The Seeing Phase of Illuminating Engineering." The Dean of the College, Dr. Frederick Kushner, explained "The Curriculum in Optometric Education." Dr. Charles Ott, Director of the Department of Visual Training, told of "The Relationship of Seeing and Learning." The Director of the College's Eye Clinic, Dr. Walter Yasko, spoke on "Clerical Practice and the Seeing Problems Encountered." Dr. Thaddeus Murroughs, Director of the Laboratory of Binocular Seeing, had for his topic, "Applications of Illuminating Engineering in Visual Psychology." Dr. Carl Shepard, Director of Research for the College, discussed "Research in Seeing."

At the conclusion of the program, the entire group was taken on a tour of the classrooms, the laboratories, and the Clinic. Northern Illinois College of Optometry, now in its 80th year, maintains one of the largest eye clinics of any optometric college. As part of the curriculum, undergraduates are assigned to specific duties in the Clinic, under the direction of Dr. Yasko and a staff of optometrists and ophthalmologists.

According to Arthur P. Larson, Secretary of the Chicago Section, the group has been invited to return to the College for a future meeting.

Enrollment of Engineering Students Increases in Canadian Schools

Registration of first year engineering students at Canadian universities is 34 per cent higher this year than last, according to the annual survey just completed by the Engineering Institute of Canada.

This survey indicates that 2865 first year students registered in engineering courses for 1952-1953 as compared to 2105 for 1951-1952 and 1874 for 1950-1951. The percentage increase last year was 14 per cent, so that there are now approximately 50 per cent more students taking first year engineering than there were two years ago.

For the first time in some years enrollment of engineering students in all years is up from the previous year by a small margin and the total registration is 8230.

The number in the graduating classes is again lower than a year ago, amounting to 1357, which is more than 20 per cent less than the number registered in 1951-1952. A still further reduction is forecast for the 1954 graduating class but in 1955 a small increase may be expected.

The relative proportion of total registration in different courses continues to show little change from previous years.

New Home Magazine Launched

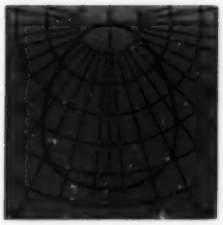
The publishers of *Small Homes Guide* have announced a new magazine in the home modernizing field. Its name will be *Home Modernizing* with an initial print order of 350,000. The first edition will appear on newsstands March 1, 1953.

The new magazine will be issued twice each year, Spring and Fall. While the *Guide* will continue to serve the new home building market, *Home Modernizing* will be edited to reach only those families who are in the mood to do major improvements on their present homes, or who plan to buy and remodel older homes.

According to the publisher, W. Wads-

(*Continued on page* 19A)

ATLANTA Residence Lighting Forum, sponsored by the Georgia Section, I.E.S., held its first dinner meeting of the year on November 3. With seven new members introduced at the meeting, total attendance was 68. Miss Edith Buchholtz was guest speaker.



LIGHTING EFFICIENCY

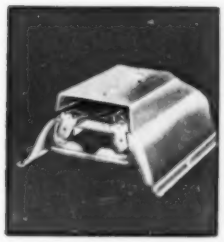
35° crosswise, 41° lengthwise shielding combined with high utilization.

Choose THE NEW 5500 SERIES GARCY recessed troffers

...because of these "ENGINEERED-IN" features

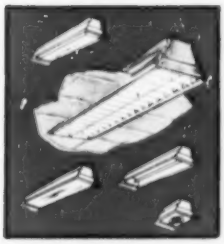
ONE PIECE LOUVER

Punched and formed in one piece with continuous outer frame for lasting rigidity. New, simplified hinging reduces maintenance.



UNIQUE COUPLING PLATE

- Lets light pass from one unit to next for more uniform brightness throughout the run.
- Wide open wireway for fast splicing.
- Simple, bolt-together coupling.



VERSATILITY

- For any type ceiling.
- 1, 2 or 3 lamp rows.
- 4, 6 or 8 ft. lengths.
- Standard fluorescent or slimline.
- Varied bottom treatments, including louvers, diffusing glass, flat or curved lenses.
- Matching Spot-a-Lites available.

GARDEN CITY PLATING and MFG. COMPANY
1760 North Ashland Avenue
CHICAGO 22, ILLINOIS

1 COMFORT FOR INDUSTRY. Die-embossed apertures in reflectors provide 10% uplighting for improved visual comfort and freedom from irritation and nervous fatigue due to eyestrain.

2 COOLER, CLEANER OPERATION. A gentle flow of air passes through apertures reducing dirt and dust deposits. This "breathing" action keeps fixture cooler, cleaner and more efficient.

3 TURRET* SOCKETS. Sturdy, vibration-proof Turret sockets are standard equipment on all CFI Day-Lines — providing positive lamp seating and simple lamp installation or removal.

*® G. E. Co.

4 ALL-WHITE PORCELAIN REFLECTORS. Outside as well as inside, every inch of reflector surface is finished in snow-white porcelain enamel—providing maximum high reflection surface for greater efficiency.

5 WIPED REFLECTOR EDGES. Excess porcelain enamel is carefully wiped away from reflector edges—an extra operation that eliminates chipping and crazing of the finish at a most vulnerable spot.

6 bonus advantages you get with CFI Day-Line® Industrial fixtures

6 NEW LOW COST. *CFI Day-Line prices are substantially lower because of improved construction methods.* Get the full CFI Day-Line story. Write today for Bulletin OD-568—the story of COMFORT FOR INDUSTRY at new low prices!

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis 7, Mo. In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario.

288

(Continued from page 16A)

worth Wood, the reaction of manufacturers, advertising agencies, and dealers alike is that the timing has been almost exactly in accord with the intense present interest in home modernizing subjects.

Surveys indicated that some 25,000,000 families own the homes they live in, but more than 11,000,000 of these homes are 33 years old — 16,000 are more than 23 years old, and 19,000,000 at least 13 years old. The millions of G.I.'s who have purchased homes of 1,000 square feet and under are already in the market for additional space due to the unusually high birth rate of the last several years — almost 4,000,000 per year, according to the survey.

American Home Makes Survey on Lighting Purchases

Close to 95% (94.8) of American families buying lighting fixtures choose their own fixtures rather than leave it to a contractor, according to a survey recently completed by the Reader Consumer panel of *American Home* magazine. In addition, 68.3% of the panel members say they have bought lighting fixtures for their homes within the past ten years. Of this group, 80.4% bought incandescent, and 54.4% bought fluorescent. (Total exceeds 100% because some respondends bought both.) Most fixtures (45.8%) were bought for kitchens. Bedrooms (32.3%), bathrooms (29.6%), and dining rooms (28.9%) follow in order of fixtures bought for specific locations. Among types of equipment purchased according to the survey, flush ceiling fixtures were most favored (59.3%), while hanging ceiling (55.8%), wall brackets (41.6%), and recessed fixtures (16.6%) followed in that order.

The magazine's Reader Consumer panel is composed of about 2,000 *American Home* subscribers.

School Lighting Clinic Scheduled in Chicago

A School Lighting Clinic, of considerable interest to school administrators, has been scheduled for presentation March 6, 1953 in Chicago. The program is being sponsored by the Chicago Section and is under the direction of Paul Fisher, Public Service Co. of Northern Illinois, as Clinic Chairman. The clinic will be held in the Commonwealth Edison auditorium, Chicago, and will feature some twelve outstanding speakers on various phases of school lighting. A tentative program includes:

Lighting the Schools — by The F. W. Wakefield Brass Co., Vermilion, Ohio.
Is Daylight Available! — by Clint Youle, Chicago's Television Weatherman.
The Way To Attain Pleasant Surroundings — by James A. Meacham, Sherwin-Williams Co., Cleveland.
Measure Your Lighting — by R. J. Diefenthaler, General Electric Company.
School Work Made Easier — by Carl J. Allen, School Lighting Specialist, Nela Park.
Short Cuts to Good Wiring — by Mike Feron, Sam Lewis Engineering Consultants.
Question Forum.
What Sources Are for Schools!—by Carl Jensen, Westinghouse Lamp Division.
You Can Light Your Classroom — by George Gilleard, Curtis Lighting Inc.
Libraries, Drafting and Shops Are Important— by R. D. Bradley, Daybrite, St. Louis.
Play Has a Light Plan — by Benjamin Electric Co.
Lighting for School Dramatics — by Dr. T. Fuchs, Northwestern University Theatre.
Keeping It Clean — by Sylvania Electric Products, Ipswich.
Question Forum.
What About It? — by G. K. Hardacre, President, Chicago Lighting Institute.

Chairmen for morning and afternoon sessions will be educators from public and parochial schools.

The regular monthly Chicago Section meeting March 6 will join the Clinic at the Chicago Lighting Institute for a "Tour of School Installations" being presented at the Study Club and at the regular meeting, "Selection of Quality Luminaires in the Milwaukee School System," by L. V. James. The latter subject covers the "Milwaukee Method" for fixture appraisal and selection.

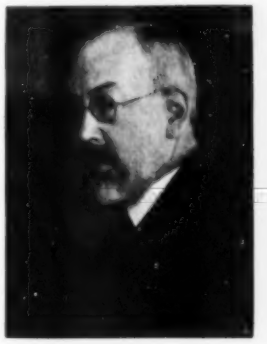
Record Attendance at Annual Light for Photography Course

Close to 1500 people took the five-day course conducted by the Chicago Lighting Institute November 10 through 14, on "Creating Pictures with Light." The course included ten sessions of discussion and demonstrations on the application of artificial light in photography, given in cooperation with the Chicago Area Camera Clubs Association and the Associated Amateur Cinema Clubs.

The ten practical sessions included in the course covered the subjects of:

Stereo Photography — by A. T. Lewis.
Making Flash Pictures Sing — by Harold Carter.
Let There Be Light — by C. K. Ainsworth.
Focusing on Floodlamps — by Richard Blount.
Speedlight Comes of Age — by James P. Kennedy.
Pictures for Publication — by Wallace Kirkland.
Movie and Slide Showmanship — by Harris Tuttle.
Lighting the Homie Movie Set—by Jack Lieb.
Lighting for Color — by Philip Letourneaux.
Creating Pictures with Light — by Harry Shigeta.

OBITUARY



Samuel E. Doane

Samuel Everett Doane, 82, internationally known lamp and lighting pioneer, past president of the Illuminating Engineering Society, and former head of Nela Park's Engineering Division, died December 9 at his home in Pine Orchard, Connecticut.

Mr. Doane was known internationally for his work in organizing international cooperation amongst lighting interests abroad, and was a leading figure in the establishment of Phoebus organization in Switzerland. One of his most valuable contributions, though but one of many, was his work in the standardization of screw bases.

A native of Swampscott, Mass., where he was born in 1870, Mr. Doane attended high school there. At the age of 16 he joined the Thompson-Houston Company at Lynn, Mass., where for six years he was tutored in mathematics and electrical engineering by Elihu Thompson, founder of one of the two companies which later became General Electric. He joined General Electric in 1892 as assistant engineer of the Harrison Lamp Works, Harrison, N. J. In 1897 he became superintendent of the Bryan-Marsh Company at Marlboro, Mass, and in 1901 was named chief engineer for the National Lamp Association, for which Nela Park was named, in Cleveland. He retained this title when the association became the National Lamp Works of the General Electric Company.

The Engineering Department of the National Lamp Works, as it was then known, became the stepping stone, under his leadership, for scores of graduate engineers entering the lighting business. Many engineers who entered the business

(Continued on page 22A)

An analysis of lighting systems for today's classrooms . . .

CLASSROOM REQUIREMENTS

ceilings . . white to reflect maximum light
walls . . . canary yellow and aquamarine to promote comfort, avoid monotony
desks . . . light (non-gloss) to avoid glare
layout . . . 3 continuous rows for best appearance, minimum wiring
system . . . semi-indirect for maximum comfort
illumination level . . . 75 footcandles

Semi-indirect lighting

Lighting at its best

A classroom should be pleasant and comfortable, and the lighting system should be an inconspicuous part of the background. That's why semi-indirect fluorescent lighting, which directs most of the light to the ceiling, is the best in classroom lighting. The entire ceiling becomes a part of the lighting system; all lamps are completely shielded.

Westinghouse Type CD Plastic Luminaires, used in this model classroom, are designed to blend with the light ceilings and easily become an integral part of the room.

This is the best, but not the only method of lighting classrooms. Westinghouse has a complete line of fluorescent and incandescent luminaires which meet classroom requirements. For an analysis of these methods get B-4556, The ABC Plan for School Lighting, Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE... IF IT'S

Westinghouse

LIGHTING DIVISION

Edgewater Park, Cleveland, Ohio

J-04512

(Continued from page 19A)

in the '20's and who now occupy key positions throughout the industry, are known to this day as the "Sons of Sam."

From the early days of the Illuminating Engineering Society, Mr. Doane was a leader in Society affairs, and in 1919-1920 was elected President of I.E.S. He was a Fellow of the American Institute of Electrical Engineers, a member of the American Society of Mechanical Engineers, the Franklin Institute, the Ohio Electric Light Association, the Electric League of Cleveland, and was a charter member of the Cleveland Art Museum. In 1927 he received an honorary degree in Electrical Engineering from Case Institute of Technology.

Mr. Doane retired from business in 1930 after which he did extensive traveling, including a two year trip around the world. In 1940 he built a colonial house in Pine Orchard, Conn., where he lived until his death after a brief illness. He is survived by his wife, Marion Jackman Doane, a son Edward E., and a daughter Dorothy.

Willard A. Anderson, Mechanical Superintendent, Government Printing Office, died recently at his home in Silver Spring, Maryland, after a long illness. Mr. Anderson, an active member of the Capital Section of I.E.S., was particularly interested in the application of color to interior decoration.

ABOUT PEOPLE

The appointment of **Charles H. Goddard,** Past President of I.E.S., to the newly created post of manager of marketing and product planning of the Lighting Division of Sylvania Electric Products, Inc., has been announced. His offices will be at headquarters of the Lighting Division in Salem, Mass. Mr. Goddard will be responsible for the planning of new products, the refinement of existing product lines, and the development of marketing procedures necessary to gain public acceptance of new products.

The appointment also has been announced of **Raymond K. McClintock** to the post of manager of new product promotion for Sylvania Electric Products, Inc. Mr. McClintock's headquarters will be at the company's executive offices at 1740 Broadway, New York, N. Y. Mr. McClintock will be responsible for fostering the promotion and sale of new products and for exploratory work leading to the consideration of new lines. Before joining the Sylvania organization, Mr. McClintock worked for the Philco Corp. and Consolidated Edison Co. of New York.

Neal Jacobus has joined the organization of **Erwin S. Burrows,** in Buffalo, N. Y., as an electrical engineer. Mr. Jacobus was formerly with Sylvania Electric Products, Inc.

Unistrut Products Co. has appointed five new district salesmen who will have headquarters in the following offices: **T. G. Greene,** 1321 Spring St., N. W., Atlanta, Ga.; **Keith H. Long,** 785 Market St., San Francisco, Calif.; **Albert E. Serewicz,** 1013 W. Washington Blvd., Chicago, Ill.; **Sherman White,** 74 Woolsey St., Irvington, N. J.; **George T. McKay,** 1450 East 33rd St., Cleveland, Ohio.

The appointment has been announced of **Roy Edwards** as sales manager of the Eastern Fixture Co., Boston, Mass. Mr. Edwards was formerly New England sales engineer.

Matthew A. Cabot has been named Western Sales Manager for Day-Brite Lighting, Inc., covering eleven Western states with headquarters in San Francisco.

L. F. Hickernell, chief engineer, Anaconda Wire & Cable Co., has been elected a member of the Board of Directors of the American Institute of Electrical Engineers with a term running through July 1954. Mr. Hickernell replaces **W. J. Barrett** who was elected Treasurer. Mr. Barrett is Electrical Coordination Engineer for the New Jersey Bell Telephone Co., Newark, N. J. **N. S. Hibschman,** Dean of the School of Engineering, Pratt Institute, Brooklyn, N. Y., has resigned as Treasurer to accept a headquarters staff position as Assistant Secretary.

Charles R. Long, Pacific Coast District Lamp Engineer for Westinghouse Electric Corp., has transferred his headquarters from Los Angeles to 410 Bush St., San Francisco. At the same time the appointment of **Earl F. Larson** as South Pacific Coast district lamp engineer has been announced. This position, newly created, will have headquarters at 600 St. Paul Ave., Los Angeles.

John W. Hamilton has joined Day-Brite Lighting, Inc., as Architectural Representative in the New York office at 92 Liberty St.

Endicott Newhall has been named sales manager of the new Electronic Transformer Department of Sylvania Electric Products' Lighting Division. Mr. Newhall has been with Sylvania since 1931 and was recently merchandising supervisor of the ballast and transformer activity.

The C. O. Jelliff Manufacturing Corp. has appointed **J. J. Glenn & Co.,** 605 W. Washington Blvd., as their representative covering electrical resistance wire in Illinois, Indiana, metropolitan Louisville and Owensboro, Ky.

J. A. Stollman has been appointed Southeastern district representative for General Electric's Construction Materials Division. In this assignment he will cover the Jacksonville, Fla. wholesale trading area.

The **Ted Jorgensen Co.** has been appointed sales agent in the New York area for Lighting Products, Inc., Highland Park, Ill. Mr. Jorgensen has been active in the lighting field since 1936.

The Condi-Lite Corp. announces the appointment of **William E. Toll** as New England District Sales Engineer. Mr. Toll will cover the states of Maine, New Hampshire, Vermont, Massachusetts and Rhode Island.

Gilbert K. Hardacre, manager of sales promotion, Commonwealth Edison Co., has been re-elected president of the Chicago Lighting Institute. **Darwin Curtis,** Chairman of the Board of Curtis Lighting, Inc., was elected vice-president; **M. W. Ross,** Commonwealth Edison Co., was elected secretary-treasurer, and **Carl W. Zersen,** assistant secretary-treasurer. **Arthur Larson,** Commonwealth Edison Co., was appointed chairman of the technical committee; **Glenn M. Boyd,** Public Service Co. of Northern Illinois, as chairman of the committee on management, and **Carl F. Jensen,** Westinghouse Electric Corp., as chairman of the committee on lighting education.

IT SEEMS TO ME

Would an Earthquake Damage *Your* Lighting System?

Earthquakes do hit the Pacific Coast region — and on July 21, 1952, at 5:42 a.m., an earthquake of 7.5 intensity hit California. The epicenter of this quake was about 100 miles north of Los Angeles. The general effect in Los Angeles was nearly nil. Three or four windows were broken and one, only, lighting fix-

(Continued on page 25A)

Designed by Herbert G. Moore, I.D.I., using Leader TROFFERLITES with egg-crate louver. Photos by Nowell Ward & Associates.

Leader LIGHTING

for *Interiors of Distinction*

RECESSED TROFFERLITE

Most versatile of all fine Leader fixtures. Available in 12" or 24" width, regular or shallow depth, in lengths from 24" to 96". Choice of shielding: plastic or steel louver, steel baffles, specialized glass enclosures, or new Lucite plastic "Lenspanel." Also available in open style.

OFFICER

Called "America's most beautiful fluorescent fixture," the OFFICER is available in 24" to 96" lengths, for 2, 3 or 4 lamps. Steel housing and channel, plastic side panels, injection moulded plastic louver with choice of 45° or 31° shielding. Use individually or in continuous rows.

■ Leader fine lighting fixtures are at home in the most distinctive interiors . . . and as efficient in operation as they are beautiful in appearance. The finest in modern design, precision engineering, and skillful fabrication from highest quality materials, characterize all Leader fixtures.

Two of Leader's most popular fixtures for use in fine interiors are the recessed TROFFERLITES and the OFFICER series. A wide range of models in each series provides greatest flexibility in meeting individual lighting requirements.

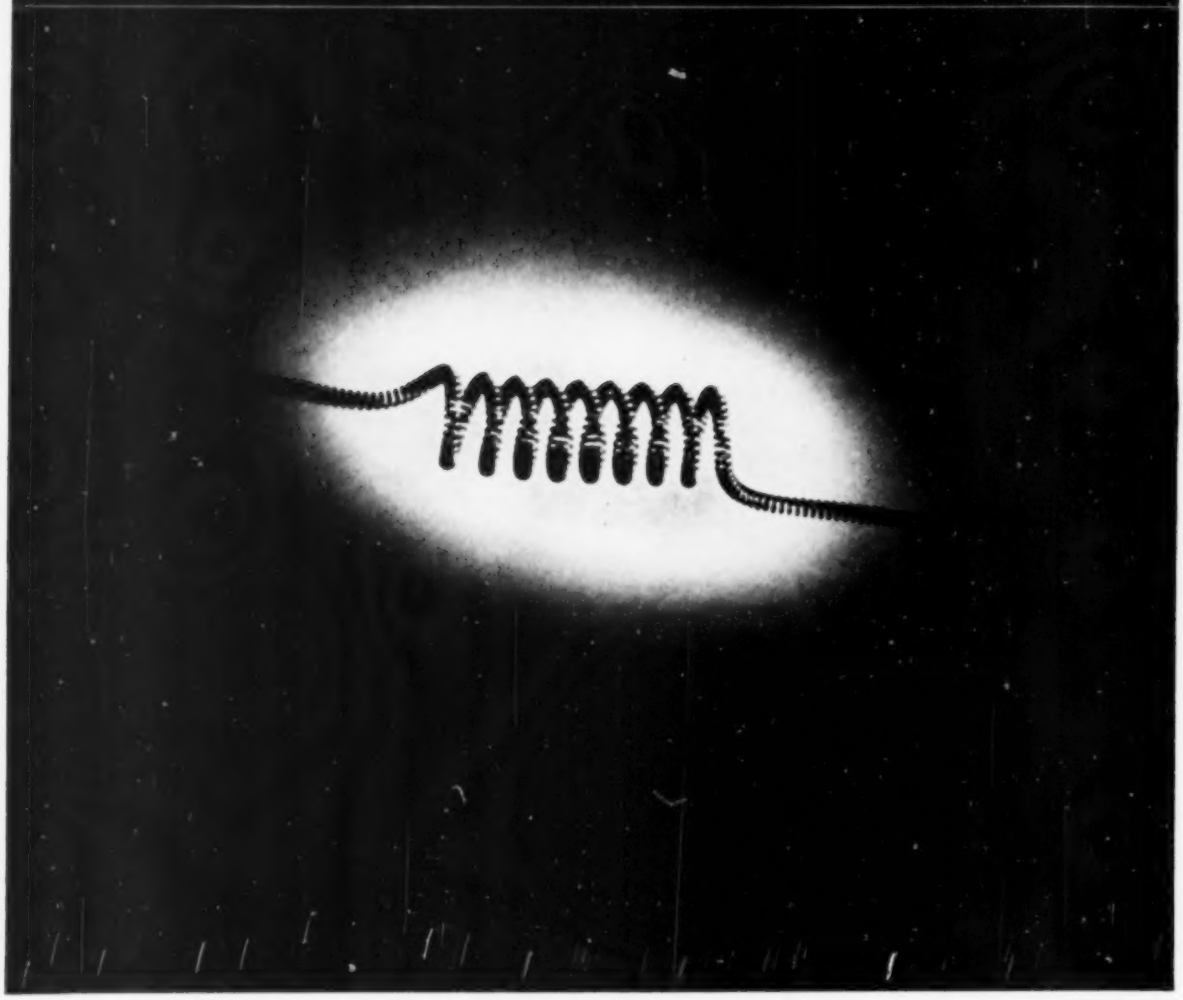
Ask for full information on these and other Leader units for business and industry. Put Leader lighting to work for YOU!

Sold and installed by the better electrical wholesalers and contractors

Leader *America's No. 1 Lighting Equipment Manufacturer*

LEADER ELECTRIC COMPANY • 3500 North Kedzie Avenue • Chicago 18, Illinois
Leader Electric—Western • 800 One Hundredth Avenue, Oakland 3, California
Campbell-Leader, Ltd. • Brantford, Ontario • Canada

You expect the best value from G-E fluorescent lamps



Extra twist squeezes more light from G-E slimline lamps

The electron flow that lights a fluorescent lamp is started by a special chemical mix held on tungsten filaments at each end of the lamp. How long the lamp lasts depends in part on how long the chemical clings to the filament. In most lamps, the filament is twisted into a double coil, to hold a quantity of the mix in a firm grip.

General Electric goes a step further by giving the double coil a third twist—making a triple coil. Used in G-E slimline and other instant-start fluorescent lamps, the triple coil holds more mix, holds it more firmly. It gives extra light for your money because it makes the lamps last longer. It's another example of why you can expect the best value from G-E fluorescent lamps.

You can put your confidence in—

GENERAL ELECTRIC

(Continued from page 22A)

ture installation was badly damaged. The circumstances involved in this disaster fully justify this recital, and lighting fixture manufacturers should try to avoid any repetition of this expensive break when fixtures are to be installed in known quake areas.

The Prudential Insurance Company western home office building is located at 5757 Wilshire Boulevard, well outside the central business area. It is a steel and concrete structure with a 13-story central tower for elevators and stairways. Immediately back of the tower two 11 story wing structures meet end to end, thus forming a 60′ x 400′ long rectangular floor area. Nine floors of the wing sections are occupied as office space and there are about 2000 Prudential employees. The first floor is occupied by commercial concerns. There is no basement area.

The building is mounted on a flat steel and concrete pad and the steel frame structure was purposely designed to sway a maximum of about 15 inches at the top. The Prudential Company carried building earthquake damage insurance in Lloyds of London. The annual premium is quoted at about $22,000 per year. Quake damage to the structure was nearly negligible. Only the lighting fixtures in office space above the third floor were affected.

The lighting fixture is a 48 inch two-lamp 40 watt fluorescent pendent unit with a corrugated polystyrene bottom and two plastic sides. Each unit contains an auxiliary and two starter cartridges. The units are mounted and bolted solidly end to end, 96 fixtures per row, 2 rows per bay and for ordinary occupancy, usually six rows per floor. Each row of 96 fixtures, 384 feet total length, represents about 2500 lbs. of total weight. Each unit in the row was suspended from a 10 ft high ceiling by a single 24″ x ¼″ diameter aluminum rod threaded at each end. The rod was hung rigid in a small crowfoot attached to the ceiling and this crowfoot was neatly housed in a small aluminum canopy. The lower end of the rod rigidly supported the fixture. There were no links in the support system. An electric feeder supply line is attached to each tenth fixture through a vertically housed fixture stem and canopy, which covers a ceiling outlet box. Energy for each fixture was supplied from a bus line of AVA wire housed within the fixtures. Note the continuous rows of fixtures and the ceiling suspension rods in the photographs.

Post quake inspection indicated that the oscillations were about parallel with the long length of the fixture. This was evidenced by the imprint of the end of the fixture in the wall plaster at each end of the row. Strangely enough, the suspension rod broke at the lower end and let the fixtures fall on desks, cabinets, partitions, floors, etc. This of course damaged the plastic housing, the lamps, the frames and some of the auxiliary units — also the desk and cabinet surfaces. The most serious and unpredictable damage was done to the wiring, which frequently broke above and beyond the ceiling outlet box. Exactly 3301 fixture units out of the total of nearly 5000 units in the building had to be replaced in whole or in part. Approximately 50,000 feet of new wire was required to repair circuit feeder and fixture bus lines.

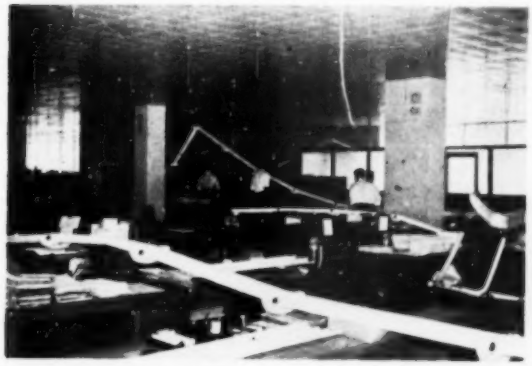
Remember, the fixtures fell at 5:42 a.m. By 8 a.m. repair crews were busy installing pigtail sockets and exposed incandescent lamps and/or subfeeds attached to the old ceiling outlets to supply temporary light so that employees could go back to work. Work was generally resumed within 24 hours. Immediately following insurance inspection, plans were made to re-fixture the damaged area. The units were replaced at a rate of about two rows, 200 fixtures per day. The same type luminaires, lamps and auxiliaries were used, but the suspension rods were changed to steel and links were added for flexibility.

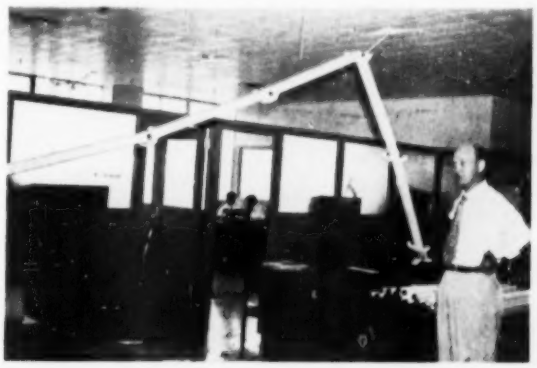
B. J. Hartmann of Flood Light Service, Inc., Los Angeles, member of I.E.S., who regularly furnish the maintenance and lamp replacement service for the above and other Prudential office buildings, were selected to do the re-fixturing job. This company operates twenty-eight service trucks and crews and does an extensive lighting maintenance business in the South Pacific area and elsewhere throughout the country. WILLIAM P. (TEDDY) BEAR, *Member Emeritus, I.E.S., Van Nuys, Calif.*

Conference Paper Deadline Is February 1st

Authors wishing to present papers at the New York Conference in September must submit triplicate copies of a brief outline of their paper by February 1st to:

Dr. R. M. Zabel
Chairman, Papers Committee
Westinghouse Electric Corporation
Bloomfield, N. J.





Two views of the damage to the lighting installation at the Los Angeles Prudential Insurance offices in last summer's earthquake. Rigid support in hanger design was felt to be the major cause.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, N. Y. December 11, 1952, the following were elected to membership.

ALAMO CHAPTER

Associate Member:
Acock, Hugh, Glidden Engineering and Equipment Co., Houston, Texas.

BRITISH COLUMBIA SECTION

Associate Member:
Williams, G. A., Canadian General Electric Co. Ltd., Vancouver, B. C.

CAROLINAS SECTION

Associate Member:
Marshall, J. W., 711 S. Tryon St., Charlotte, N. C.

CENTRAL NEW YORK SECTION

Associate Members:
Blair, J. K., N. Y. State Electric & Gas, Binghamton, N. Y.
Denning, L. A., Graybar Electric Co., Syracuse, N. Y.
Dorris, A. F., Royal Lamp Co., Utica, N. Y.
Engleman, Jack, General Electric Supply Co., Syracuse, N. Y.

CHICAGO SECTION

Associate Members:
Anderson, E. W., Public Service Co. of No. Illinois, Maywood, Ill.
Balikov, S. J., Karn Electric Service, Chicago, Ill.
Bohlman, V. R., Garden City Plating & Mfg. Co., Chicago, Ill.
Butler, C. M., Jefferson Electric, Bellwood, Ill.
Campbell, D. B., Public Service Co. of Northern Illinois, Joliet, Ill.
Davis, W. J., Armour Research Foundation, Chicago, Ill.
Field, M. S., Compco Corp., Chicago, Ill.
Green, H. F., Luxor Lighting Products Inc., Chicago, Ill.
McDonnell, E. F., Jr., Commonwealth Edison Co., Chicago, Ill.
Nuetzmann, H. A., Public Service Co. of Northern Illinois, Joliet, Ill.
Pohl, John, Public Service Co. of Northern Illinois, Joliet, Ill.
Snyder, W. M., Snyder Etsinger Sales Co., Chicago, Ill.
Swarner, J. L., Pullman Standard Car Mfg. Co., Chicago, Ill.
Van Heule, G. E., Curtis Lighting Inc., Chicago, Ill.
Weber, C. H., R. R. Donnelley & Sons Co., Chicago, Ill.

CLEVELAND SECTION

Member:
Morris, R. W., General Electric Co., Cleveland, Ohio.
Associate Members:
Bale, J. R., Westinghouse Electric Corp., Cleveland, Ohio.
Ferguson, W. B., 513 The Arcade, Cleveland, Ohio.
Kruper, T. P., Pittsburgh Corning Corp., Pittsburgh, Pa.
Summers, Theodore, Jr., Westinghouse Electric Corp., Cleveland, Ohio.
Wilson, T. R., Cleveland Electric Illuminating Co., Ashtabula, Ohio.
Woolcock, G. T., Cleveland Electric Illuminating Co., Cleveland, Ohio.
Zucker, R. J., Westinghouse Electric Corp., Cleveland, Ohio.

CONNECTICUT SECTION

Associate Member:
Chase, R. H., Hartford Electric Light Co., Hartford, Conn.

CORNHUSKER CHAPTER

Associate Member:
Huff, W. M., Omaha Board of Education, Omaha, Neb.

EASTERN NEW YORK CHAPTER

Associate Members:
Frumkin, B. A., M. Gold & Son., Schenectady, N. Y.
Shapiro, A. A., Economy Electric Supply Co., Schenectady, N. Y.

EASTERN PENNSYLVANIA SECTION

Associate Members:
Reynolds, R. A., Crouse Hinds Co., Syracuse, N. Y.
Showalter, C. R., Jr., Pennsylvania Power & Light Co., Allentown, Pa.

FLORIDA CHAPTER

Associate Member:
Wiggin, D. L., Pasco Packing Co., Dade City, Fla.

FOREIGN NON SECTION

Members:
Dunkley, H. R., Aladdin Lighting Corp., Salisbury, Southern Rhodesia, Africa.
Liebenberg, J. L., The British General Electric Co. Ltd., Johannesburg, Africa.
Associate Member:
Rubio-Cuervo, Alfonso, Leda Limitada, Carrera 21 #12-A-33, Bogota, Colombia, S. A.

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Yopp, H. T., 753 Williams St. N. W., Atlanta, Ga.
Associate Members:
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Ferry, A. L., Store Design & Commercial Interiors, Atlanta, Ga.
Freeman, Miss Elinor, Atlanta Fluorescent Co., Atlanta, Ga.
Fulton, C. H., Fulton Bros. Electric Co., Atlanta, Ga.
Hightower, C. C., Alabama Power Co., Eufaula, Ala.
Holland, A. N., Jr., Alabama Power Co., Birmingham, Ala.
Weinreb, Benjamin, Patchen & Zimmerman, Augusta, Ga.

HAMILTON, ONTARIO CHAPTER

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Sawle, R. T., Blenkhorn & Sawle Ltd., St. Catharines, Ont.

HEART OF AMERICA SECTION

Members:
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Weeks, C. B., Kansas Gas & Electric Co., Newton, Kans.
Associate Members:
Anderson, R. F., Leader Electric Co., Kansas City, Mo.
Johnson, C. M., Kansas Gas & Electric Co., Arkansas City, Kans.

INDIANA CHAPTER

Associate Members:
Francis, Hilard, Jr., 941 N. Denny St., Indianapolis, Ind.
Kaufman, W. H., Jr., Public Service Co. of Indiana Inc., Bloomington, Ind.
Keller, H. K., 5320 Norwalde, Indianapolis, Ind.
Simpson, J. C., Public Service Co. of Indiana, Plainfield, Ind.
Wells, H. B., Public Service Co. of Indiana, Connersville, Ind.
Wintin, R. M., Sylvania Electric Products Inc., Indianapolis, Ind.

IOWA SECTION

Associate Members:
Biermann, R. G., University Electric Co., Des Moines, Ia.
Goodwater, R. P., The Van Meter Co., Cedar Rapids, Ia.
Harrison, Leo, Electric Supply Co., Des Moines, Ia.
Thielking, P. W., 701 Equitable Bldg., Des Moines, Ia.

MARYLAND SECTION

Associate Members:
Dickerson, J. E., General Electric Supply Co., Baltimore, Md.
Wolfe, H. D., Consolidated Gas & Electric Light & Power Co., Baltimore, Md.

MICHIGAN SECTION

Members:
Crotser, L. W., Westinghouse Electric Corp., Detroit, Mich.
Smith, R. A., Crescent Electric Co., Detroit, Mich.
Associate Members:
Brandenburg, F. C., The Detroit Edison Co., Detroit, Mich.
deSteiger, R. R., Raymond de Steiger, Inc., Detroit, Mich.
Homer, E. P., General Electric Co., Detroit, Mich.
Scott, R. E., The Detroit Edison Co., Hamtramck, Mich.

MID-SOUTH CHAPTER

Associate Member:
Glenn, R. R., General Electric Supply Co. Little Rock, Ark.
Student Members:
Bahnsen, E. J., Southern College of Optometry, Memphis, Tenn.
Bailes, C. H., Jr., Southern College of Optometry, Memphis, Tenn.
Bierman, L. C., Southern College of Optometry, Memphis, Tenn.
Blake, G. L., Southern College of Optometry, Memphis, Tenn.
Bourland, Gene, Southern College of Optometry, Memphis, Tenn.
Chapman, J. J., Southern College of Optometry, Memphis, Tenn.
Clement, W. A., Southern College of Optometry, Memphis, Tenn.
Cowart, E. L., Jr., Southern College of Optometry, Memphis, Tenn.
Cunningham, W. J., Southern College of Optometry, Memphis, Tenn.
Demmer H. F., Southern College of Optometry, Memphis, Tenn.
Denny, R. M., Southern College of Optometry, Memphis, Tenn.
Denson, G. T., Southern College of Optometry, Memphis, Tenn.
Dooley, D. A., Southern College of Optometry, Memphis, Tenn.
Douglas, S. D., Southern College of Optometry, Memphis, Tenn.
Dupuy, B. P., Jr., Southern College of Optometry, Memphis, Tenn.
Farb, I. J., Southern College of Optometry, Memphis, Tenn.
Fouts, H. A., Southern College of Optometry, Memphis, Tenn.
Fox, M. B., Southern College of Optometry, Memphis, Tenn.
Grimes, F. B., Southern College of Optometry, Memphis, Tenn.
Gullard, A. S., Southern College of Optometry, Memphis, Tenn.
Hagen, T. G., Southern College of Optometry, Memphis, Tenn.
Harpe, R. K., Jr., Southern College of Optometry, Memphis, Tenn.
Hawks, T. W., Southern College of Optometry, Memphis, Tenn.
Heiman, Hertzl, Southern College of Optometry, Memphis, Tenn.
Keaton, H. L., Southern College of Optometry, Memphis, Tenn.
Krell, Norman, Southern College of Optometry, Memphis, Tenn.

(Continued on page 32A)

A NEW APPROACH
TO QUALITY LIGHTING

THE
GILL-GLO

LUMINOUS
SILVER BOWL
LAMP LUMINAIRE

FOR THE FIRST TIME
SHIELDING ASSEMBLY SOLID
ONE PIECE *LUMINOUS* PLASTIC

7 POINTS OF ACHIEVEMENT

1. High efficiency—86% light output
2. Simplicity—Open ring shielding with translucent plastic louvers.
3. Good brightness—No opaque light shielding parts.
4. Low maintenance costs—No hard to clean surfaces
5. Rugged construction—porcelain socket to withstand high temperatures. Entire fixture securely locked at all points.
6. Uniformity. Uniform light output throughout lamp life.
7. Good appearance. Blends successfully with any type of architecture.

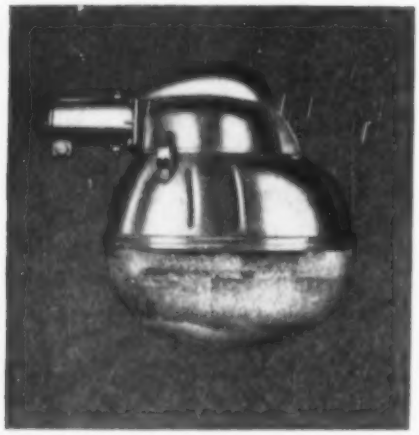
HIGH QUALITY

LOW INITIAL COST

GILL GLASS and FIXTURE CO.
PHILADELPHIA established 1876

BOTH HIGH-SPEED SAFETY AND LOW MAINTENANCE COST MADE POSSIBLE WITH G-E FORM 109 LUMINAIRES.

Safe speed with G-E Form 109's on two New Jersey Turnpike bridges



G-E FORM 109 features rectangular pattern, uses mercury or filament, gives economical mercury-lamp operation with magnetic coil.

NO NIGHT FATALITY has occurred on the two New Jersey Turnpike bridges illuminated by G-E Form 109 Luminaires, despite heavy traffic averaging 84,000 vehicles during every 24-hour period. The Form 109's make safe, high-speed driving possible where the New Jersey Turnpike bridges the Hackensack and Passaic Rivers, and warn motorists of the change from the usual straight-away travel.

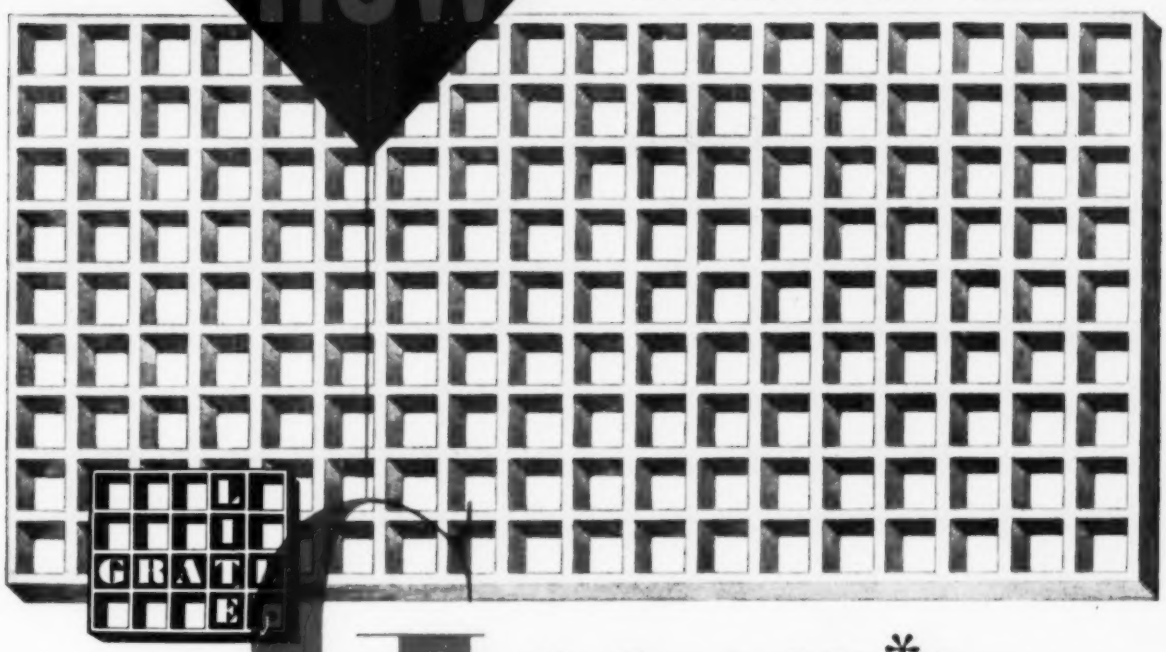
USE FILAMENT LAMPS. Average intensity of 0.6 footcandles on the concrete roadway is provided by 133 G-E Form 109's equipped with 10,000-lumen, 20-ampere filament lamps, at a mounting height of 30 feet to light center, with 100-foot staggered spacing. Poles are isolated from the road area with a special bracket mount which mounts them over the side of the bridge structure.

LOW MAINTENANCE. The G-E Form 109 luminaire gives you the flexibility of using either mercury or filament lamps, the economy of G-E standardization, and extremely high light utilization. You are assured of minimum maintenance cost with quick, easy relamping and low glassware breakage. For information, ask your G-E representative for Bulletin GEA-5419. Or write Section 452-135, General Electric Company, Schenectady 5, New York.

GENERAL ELECTRIC

new

OPEN LIKE A LATTICE
DIFFUSING LIKE GLASS



Guth GrateLite* Louvre

the latest idea in lighting

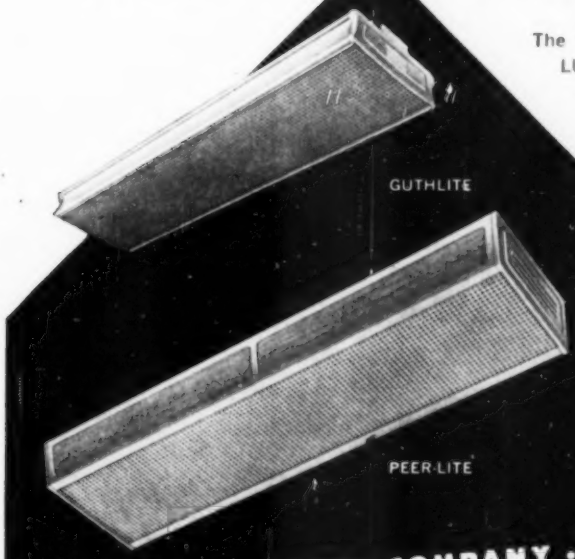
A SYMPHONY OF DIFFUSED LIGHT

*U.S. & Can. Pats. Pend.

The first integral plastic louvre for fluorescent lighting, molded of LUSTREX polystyrene. It reveals a new conception of architectural beauty and efficient lighting: Its diffusion results from the ⅜" cubical lattice that cuts off direct light at a 45° angle.

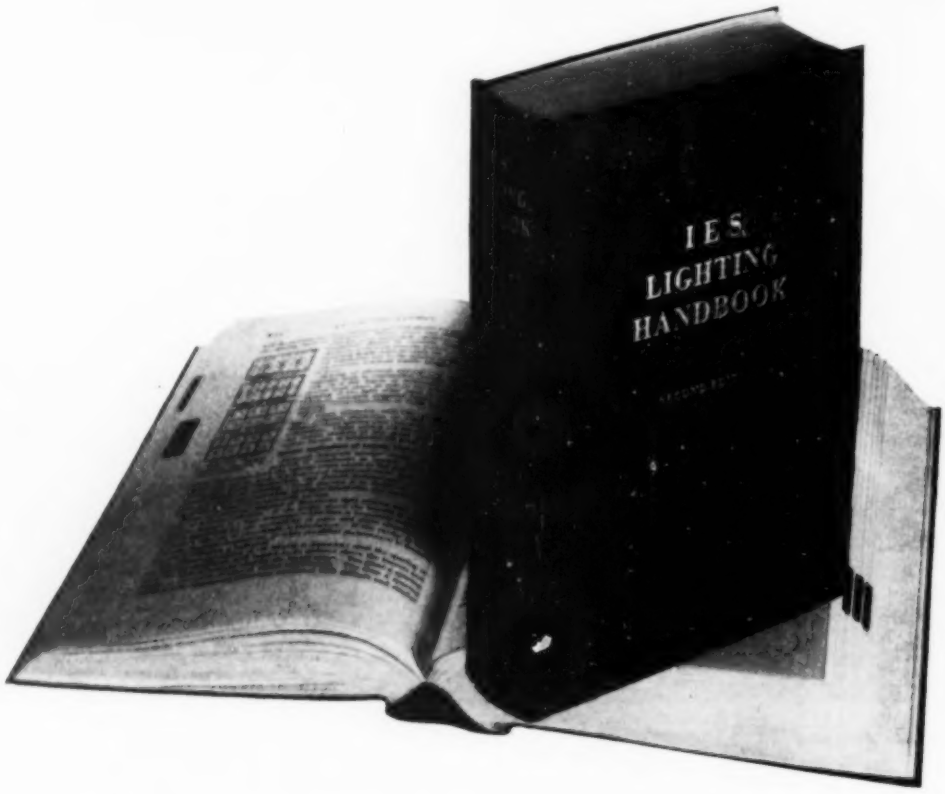
But words alone cannot describe beauty. See for yourself and ask to be shown a sample. It will give you a new outlook on lighting.

GrateLite is tough, quickly cleaned and de-staticized. It is furnished in one piece with Guth Fluorescent Fixtures.



LEADERS IN LIGHTING
Guth
SINCE 1902

THE EDWIN F. GUTH COMPANY · ST. LOUIS 3, MO.



bible

According to Webster: "bible (non-capitalized)—a book looked upon as authoritative . . ."

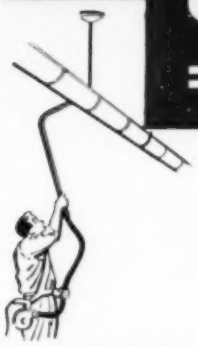
According to illuminating engineers: "The I.E.S. Lighting Handbook"—987 pages of authoritative information on light, lamps and lighting, and probably the Society's most important single contribution to the advancement of lighting knowledge.

Thousands of well-thumbed copies on desks throughout the world recently made way for the handbook's Second Edition—product of two years' work by 34 committees, and an outstanding result of the pooled talent and time of leading illumination specialists, made available to all by the

Illuminating Engineering Society

Formula for optimum lighting efficiency:

Quality + Cleanability = the Wakefield STAR



Making Light Work of It with Wakefield Maintenance Equipment

By using this blower-type Wakefield maintenance equipment, the janitor can keep Stars clean by spending five minutes a day once every three weeks in each room. For yearly washing of reflectors, lamps and channels, the janitor removes the reflectors (they slide in and out like a drawer) and uses an ordinary detergent.

Note: the Wakefield maintenance equipment shown is available free to purchasers of Stars in specified quantities. We will gladly give you details.

There are good reasons why the Star is recognized as a superior classroom luminaire and why it is so often recommended for "Co-ordinated Classrooms" (as well as offices, drafting rooms and other areas where critical seeing tasks are performed).

QUALITY OF LIGHT. Luminous Plaskon reflector sends most of the light to the ceiling, to be distributed evenly all over the room. Result: a minimum of reflected glare. The reflector, which completely hides the lamps, has about the same brightness as the ceiling. Result: a minimum of direct glare.

CLEANABILITY. The Star is one of the most easily and completely cleanable of luminaires. See column at left.

RECENT TESTS of actual installations, using the interflection method, indicate fewer Stars are required to light a room at a given level than had previously been thought necessary. We will be glad to send you the new coefficient of utilization tables.

The Star is equipped for pre-heat and rapid-start bipin and slimline lamps. See Sweet's architectural file. Or write to The F. W. Wakefield Brass Company, Vermilion, Ohio.

Pierce School
West Newton, Mass.
Room size: 23′ x 36′
2 rows of four 4′ units
2-75 W standard warm white fluorescent lamps per unit.
Footcandles: 32 average.

Wakefield Over-ALL Lighting

for

Book Stacks

best lighting

Office File Areas

of areas

Control Panels

like these

Stock Bins

specify

Store Wall Cases

the

miller
STACKTON

Engineered for specific lighting application, the STACKTON gives you L. O. C. (Low Overall Cost):

- Designed to provide even ratio of foot candles on vertical surfaces.
- Safe—non-shattering lens of exclusive Diamond Lucite pattern.
- Reduces glare—The Diamond Lucite lens reduces glare while maintaining high efficiency.
- ETL Certified ballasts, readily accessible for easy maintenance.

WRITE FOR STACKTON CATALOG . . . MILLER field engineers and distributors are conveniently located.

THE miller COMPANY
SINCE 1844
MERIDEN, CONNECTICUT

WHATEVER YOUR LIGHTING PROBLEM . . . MILLER, Leaders in Lighting since 1844, can help you solve them with Fluorescent, Incandescent and Mercury luminaires that provide ideal lighting—easy installation — low maintenance — long life.

miller
SINCE 1844

(Continued from page 26A)

Lawless, P. B., Southern College of Optometry, Memphis, Tenn.
Levin, A. F., Southern College of Optometry, Memphis, Tenn.
McNabb, V. O., Southern College of Optometry, Memphis, Tenn.
McWhirter, B. M., Southern College of Optometry, Memphis, Tenn.
Mixson, M. E., Jr., Southern College of Optometry, Memphis, Tenn.
Neu, Herman, Southern College of Optometry, Memphis, Tenn.
Paige, T. C., Southern College of Optometry, Memphis, Tenn.
Portnoy, A. M., Southern College of Optometry, Memphis, Tenn.
Riley, J. J., Southern College of Optometry, Memphis, Tenn.
Rochon, S. C., Southern College of Optometry, Memphis, Tenn.
Scevola, A. H., Southern College of Optometry, Memphis, Tenn.
Smith, Mack, Southern College of Optometry, Memphis, Tenn.
Sterle, F. J., Southern College of Optometry, Memphis, Tenn.
Stewart, T. W., Southern College of Optometry, Memphis, Tenn.
Taylor, I. W., Southern College of Optometry, Memphis, Tenn.
Tescher, E. N., Southern College of Optometry, Memphis, Tenn.
Thomas, A. L., Southern College of Optometry, Memphis, Tenn.
Turley, J. J., Southern College of Optometry, Memphis, Tenn.
Valentine, T. P., Southern College of Optometry, Memphis, Tenn.
Weber, F. H., Southern College of Optometry, Memphis, Tenn.
Wells, K. H., Southern College of Optometry, Memphis, Tenn.
Wickstrom, L. A., Southern College of Optometry, Memphis, Tenn.

Milwaukee Section

Associate Member:
Sherkow, V. A., Standard Electric Supply Co., Co., Milwaukee, Wis.

Montreal Section

Associate Members:
Collins, W. A., The Shawinigan Water & Power Co., Victoriaville, Que.
Cote, Marcel, Ponco Transformers Ltd., Verdun, Que.
Davidson, J. F., Northern Electric Co. Ltd., Montreal, Que.
Ilson, E. L., Canadian General Electric Co., Montreal, Que.
Walker, T. C., Canadair Ltd., Montreal, Que.

Mother Lode Chapter

Member:
Ross, William, General Electric Company, Sacramento, Calif.

New England Section

Associate Members:
Bean, L. A., George D. Montgomery & Son, Waban, Mass.
King, R. F., General Electric Co., Lynn, Mass.
Mackay, Stillman, Jr., General Electric Co., W. Lynn, Mass.
McCarthy, J. P., Jr., Hayden, Harding & Buchanan, Boston, Mass.
Rubio Cuervo, A., Belco Trading Co., Brookline Village, Mass.
Yale, G. A., Stocker & Yale Inc., Marblehead, Mass.

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Roche, A. C., Woodward Wight & Co. Ltd., New Orleans, La.
Supple, J. M., EACO Inc., New Orleans, La.
Thrash, W. D., Jr., Lighting Fixture & Electric Supply Co. Inc., New Orleans, La.

New York Section

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Littell, H. P., Luminous Ceilings Inc., New York, N. Y.
Perofsky, Joseph, Modern Metal Mfg. Co., New York, N. Y.
Watkins, J. E., Silvray Lighting Co. Inc., New York, N. Y.

Northern California Section

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Calder, J. B., J. B. Calder Co., San Francisco, Calif.
Langlais, W. A., Chas. A. Langlais Co., San Francisco, Calif.
Lethine, L. M., Phillips & Edwards Electric Corp., San Francisco, Calif.
Sarcander, W. A., 2430 W. Princeton Ave., Stockton, Calif.
Shinn, E. S., Deane & Hill, San Francisco, Calif.

Ohio Valley Section

Associate Members:
Baker, D. E., Cincinnati Gas & Electric Co., Cincinnati, Ohio.
Brangan, W. J., Wente Construction Co. Inc., Hamilton, Ohio.
Hughes, D. R., Jr., Hughes Simonson Engineering Co., Dayton, Ohio.

Oregon Section

Student Members:
Jensen, L. C., Oregon State College, Corvallis, Ore.
Putnam, W. J., Oregon State College, Corvallis, Ore.
Seid, D. G., Oregon State College, Corvallis, Ore.
Wallace, M. V., Oregon State College, Corvallis, Ore.
Young, J. A., Oregon State College, Corvallis, Ore.

Philadelphia Section

Associate Members:
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Kafka, V. W., General Electric Co., Philadelphia, Pa.

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Associate Members:
Lang, H. P., Monongahela Power Co., Fairmont, W. Va.
Rickel, F. E., Pittsburgh Reflector Co., Pittsburgh, Pa.

Puget Sound Section

Associate Members:
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Bate, B. R., Carey & Kramer, Seattle, Wash.
Kirk, F. N., Theo. R. Krueger & Associates, Seattle, Wash.

Quebec Chapter

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Angers, P. C., Canadian Westinghouse Co., Quebec, Que.
Niron, Gertrude, Roger Dussault Ltee., Quebec, Que.

Rochester Section

Associate Members:
Born, R. N., Ward Leonard Electric Co., Rochester, N. Y.
Lorscheider, E. M., 704 Terminal Bldg., Rochester, N. Y.
Rohenstein, G. L., Pinnacle Electric Co., Rochester, N. Y.

St. Louis Section

Associate Members:
Carr, T. H., Westinghouse Electric Corp., St. Louis, Mo.

(Continued on page 33A)

(Continued from page 32A)

Ehrenberg, C. F., Westinghouse Electric Corp., St. Louis, Mo.
Halwe, P. R., Carl I. Schaeffer Electric Co., St. Louis, Mo.
Harris, H. H., Harris Hanson Co., St. Louis, Mo.
Kulp, D. R., Leviton Mfg. Co., St. Louis, Mo.
Sheffer, D. E., Westinghouse Electric Corp., Owensboro, Ky.
Zolezzi, E. L., Westinghouse Electric Corp., St. Louis, Mo.

SAN JOSE CHAPTER

Associate Member:
Hunter, V. L., Soby & Green, Los Gatos, Calif.

SOUTHEAST FLORIDA CHAPTER

Student Members:
Abboushi, A. K., University of Miami, Coral Gables, Fla.
Erickson, C. G., University of Miami, Coral Gables, Fla.
Fink, G. E., University of Miami, Coral Gables, Fla.
Greenhill, R. A., University of Miami, Coral Gables, Fla.
Roche, R. F., University of Miami, Coral Gables, Fla.

SOUTHERN CALIFORNIA SECTION

Member:
Nye, A. W., Los Angeles College of Optometry, Los Angeles, Calif.
Associate Members:
Brink, Guy, 2738 E. Walnut St., Pasadena, Calif.
Keating, E. F., Gough Industries Inc., Los Angeles, Calif.
Robinson, L. B., Sylvania Electric Products, Los Angeles, Calif.
Rudman, M. J., Day-Brite Lighting Inc., Los Angeles, Calif.

TENNESSEE VALLEY SECTION

Member:
Austin, R. M., Hajoca Corp., Chattanooga, Tenn.
Student Member:
Norman, H. P., III, Vanderbilt University, Nashville, Tenn.

TORONTO SECTION

Member:
Joly, Andre, 323 Marion St., Sudbury, Ont.
Associate Members:
Dickson, F. N., Amalgamated Electric Corp. Ltd., Toronto, Ont.
Edmonds, R. M., Hydro Electric Power Comm. of Ont., Toronto, Ont.

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Associate Members:
Gibb, J. H., Tri-State Electric Co., Sioux Falls, S. D.
Simcoe, J. C., Anning Johnson Co., Minneapolis, Minn.
Voges, K. H., Northern States Power Co., St. Paul, Minn.
Wollan, S. A., Kehne Electric Co. Inc., St. Paul, Minn.

TWIN PORTS CHAPTER

Associate Members:
Bevis, A. H., Minnesota Power & Light Co., Duluth, Minn.
Dobberman, M. R., 304 Board of Trade Bldg., Superior, Wis.
Flaaten, D. S., Minnesota Power & Light Co., Duluth, Minn.
Johnson, J. C., Minnesota Power & Light Co., Duluth, Minn.

WESTERN NEW YORK SECTION

Member:
Billhartz, W. H., Pittsburgh Corning Corp., Port Allegany, Pa.
Associate Member:
Hayes, W. E., General Electric Co., Buffalo N. Y.

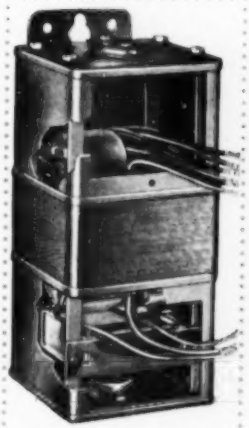
TEN GOOD REASONS

TO SPECIFY JEFFERSON MERCURY LAMP TRANSFORMERS

1. EASY MOUNTING!
Keyhole slots for easy positioning and two holes for locking bolts in both top and bottom brackets. Brackets are reversible or removable for messenger wire suspension, etc.

2. PLENTY OF KNOCKOUTS!
One-half and ¾" knockouts in sides of wiring compartments at each end. Two ½" knockouts in each end plate.

3. INCANDESCENT & MERCURY LAMP LEADS, BOTH ENDS!
For fast, convenient wiring of combination mercury vapor and incandescent lamp fixtures. Mercury lamps can also be wired from either end of transformer.



4. THREE PRIMARY TAPS!
Color-coded tagged leads for positive identification and quick wiring. 3 primary taps (not 2) for close matching with line voltage.

5. DOUBLE VARNISHED CORE & COIL!
Oven baked polymerizing varnish impregnation assures permanent insulation and protection against moisture.

6. INTERCHANGEABLE FITTINGS!
Pryouts on both ends expose standard ½" conduit fittings for suspension type mounting of transformer and/or lamp. ¾" fittings quickly interchangeable.

7. AMPLE WIRING COMPARTMENTS!
Condenser located to provide full wiring space when any knockout is used. Solid U-Bracket mounting prevents vibration damage to condenser and leads.

8. NO OBSTRUCTIONS!
Plenty of wiring room between condenser and conduit fittings. Run wiring through lamp suspension conduit . . . save time, trouble, and outside wiring.

9. PRESS FIT RIVETED CORE!
For positive uniformity of manufacture and maximum quality.

10. TRANSFORMERS FOR EVERY APPLICATION!
Indoors, or out, Jefferson Transformers fill every demand. Normal and high power factor designs. Two lamp types are H.P.F. design. Outdoor types in deep-drawn cases for positive protection against moisture.

THESE EXTRA VALUES ARE YOURS AT NO EXTRA COST!

Only in the new line of Jefferson Mercury Lamp Transformers do you find *all* the extra-value features. You get maximum operating economy, full rated lamp life, and all around lighting satisfaction.

The extra values are yours in every model Jefferson Transformer — yet the cost is no greater than that of the ordinary transformer. Investigate now. There is no obligation.

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BELLWOOD, ILLINOIS

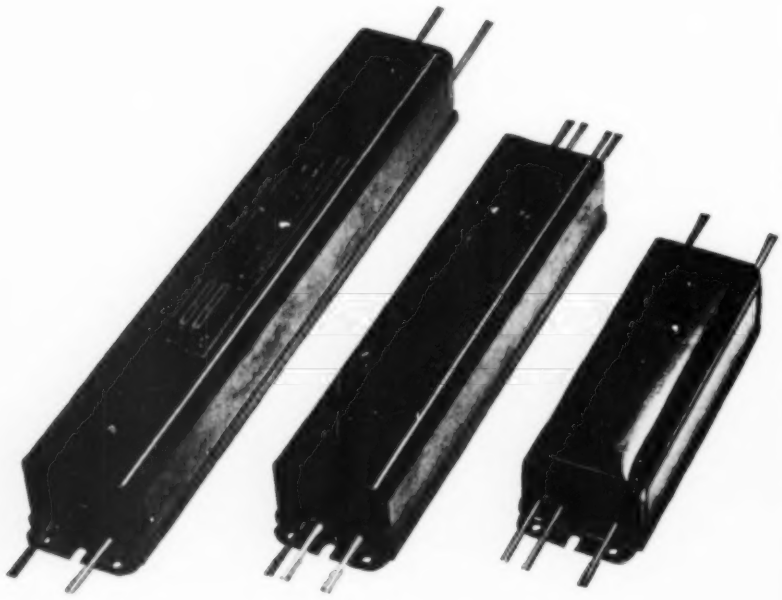
New 16 page illustrated Bulletin 521-5 gives complete data on indoor and outdoor models for all H-1 400 watt lamps, and on the new Jefferson Transformers for both H-12 and H-15 1000 watt lamps. Write for your free copy now.

Jefferson Transformers

STEP-UP the PERFORMANCE of YOUR FIXTURES with

Acme ACME Electric

BALLASTS



Let's be realistic. Fluorescent lamps need exactly the watt input for which they were designed; a 100 watt lamp will not deliver its full light output if it is limited by a ballast having an actual output of only 91.2 watts. A low watt input to lamp results in a low light output. Low pre-heat current and an excessive operating current means short lamp life. Distorted lamp current wave form leads to excessive cyclic flicker.

As a fixture manufacturer, it's *your* reputation at stake when you select ballasts for your product. Protect your good name with Acme Electric ballasts.

ACME ELECTRIC CORPORATION

291 WATER ST. CUBA, N. Y.

Acme ACME Electric

EXECUTIVE LIGHTING SALESMAN

A long recognized New York manufacturer of a complete line of architectural lighting equipment seeks distinguished representation in New York metropolitan area. Applicant must possess illumination engineering and design background and be conversant with leading architects and lighting engineers. Salary, commission and pension plan to provide for high-bracket income. All replies held in strictest confidence. Send complete resume to Box 181, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

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Graduate engineer for development in engineering design of commercial, industrial and street lighting equipment. Preferably man 25-30 years old with some experience or recent graduate of top caliber. Opportunity for permanent position and advancement with leading firm of over 50 years standing. Location—Midwest. State full details, confidential. Address Box 182, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

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The Miller Company is expanding its field sales force and agency contracts are available in the following territories: Houston, Texas Territory; Lubbock, Texas Territory. Representatives interested on an agency or commission basis are invited to communicate with The Miller Company, 99 Center St., Meriden, Conn.

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To work in engineering division of architectural firm. Lighting, wiring, power distribution. Large volume of school work. Write details of training, experience and salary desired to Wolf & Hahn, R.A., 459 Hamilton St., Allentown, Pennsylvania.

See this white, clean surface?

It shows how ***DUST FREE YOUR*** **PLASTIC LUMINAIRE PANELS** will look—FOR MONTHS —when treated ***with the New, Highly Improved***

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Sample Qt.: $3.85—Sample Gal. $8.50
In quantities, as low as $4.00 gal.
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RESEARCH LIGHTING
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the upkeep on your overhead

When our salesmen call on you, they'll sell more than lighting fixtures. They'll sell logical reasons why SOLARLITE reduces lighting costs. When you invest in SOLARLITE, you're getting the finest in engineering design . . . planned to fit your particular environment . . . planned to save you money over the years. We know it works that way because it's the reason we've stayed in business for 50 years . . . because our satisfied customers love to tell others about their SOLARLITE installations. We'd like to tell you about SOLARLITE's big part in producing better school lighting. Write for our booklet "Take our children out of the Twilight Zone."

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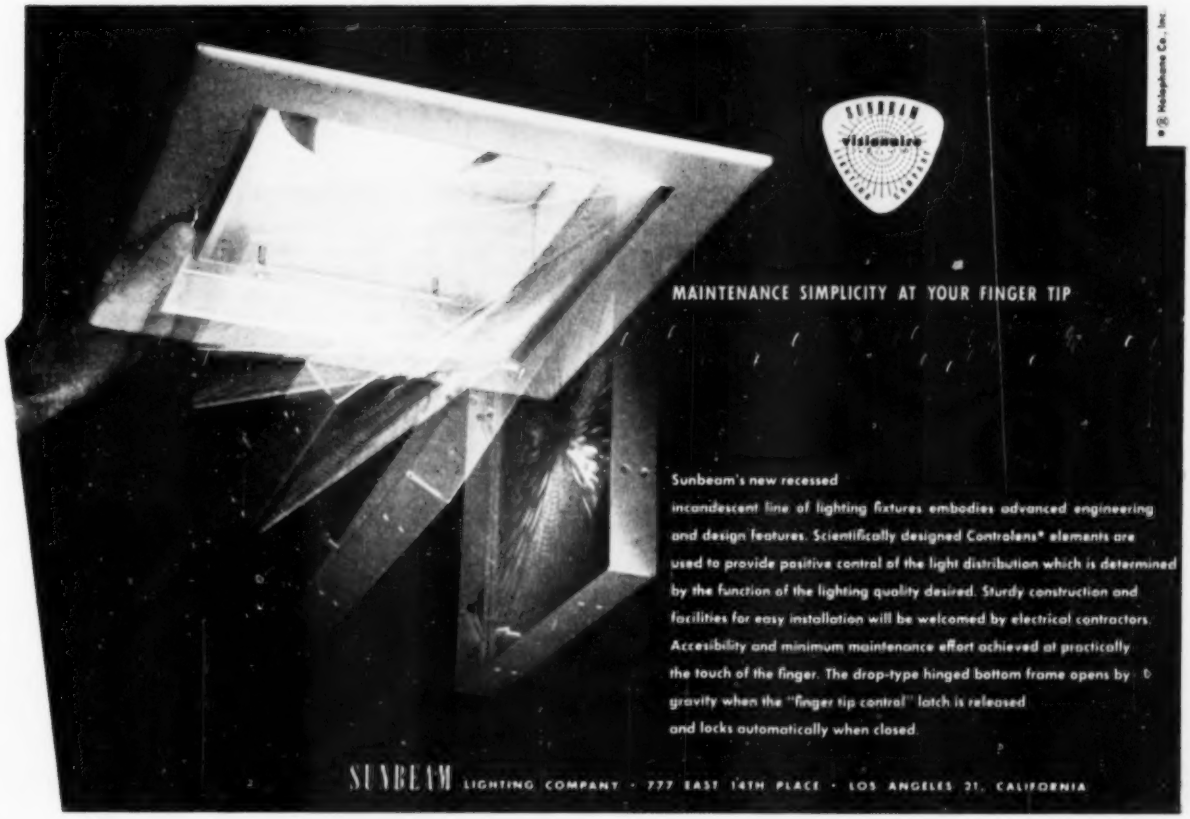
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MAINTENANCE SIMPLICITY AT YOUR FINGER TIP
Sunbeam's new recessed incandescent line of lighting fixtures embodies advanced engineering and design features. Scientifically designed Contralens* elements are used to provide positive control of the light distribution which is determined by the function of the lighting quality desired. Sturdy construction and facilities for easy installation will be welcomed by electrical contractors. Accessibility and minimum maintenance effort achieved at practically the touch of the finger. The drop-type hinged bottom frame opens by gravity when the "finger tip control" latch is released and locks automatically when closed.
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* ® Holophane Co., Inc.

Sola Mercury Vapor Lamp Transformers

Regulated or Conventional

for Indoor Lighting Installations

SOLA CONSTANT WATTAGE BALLASTS . . .

. . . continuously and automatically supply constant wattage within ±2% regardless of line voltage fluctuations as great as ±15%. This patented circuit results in the following advantages:

1. *Eliminates need for primary voltage taps*
2. *Assures positive lamp starting*
3. *Reduces line and lamp starting current surge*
4. *Eliminates voltage-drop lamp outages*
5. *Maintains constant lamp wattage, lamp current and light output*
6. *Extends lamp and transformer life.*

Single-lamp and two-lamp units are available for indoor operation of the 400 watt type H-1 mercury vapor lamps.

SOLA CONVENTIONAL-TYPE BALLASTS . . .

. . . are premium quality, non-regulated auxiliaries at moderate prices. They are designed and produced to the same high standards of quality as the Constant Wattage types.

Typical quality features include: the Sola pressed-in-core construction, leads fastened to sturdy lug straps, not merely coil ends . . . high vacuum varnish impregnation . . . pryout in each end cover exposing a ½" threaded conduit fitting . . . ½" and ¾" knockouts . . . large access panels to roomy wiring compartments.

They are available for single-lamp operation of the 400 watt type H-1 mercury vapor lamps. Three primary voltage taps are provided for proper matching to various line voltages, insuring operation at lamp ratings and resulting in full light output.

Write for complete electrical and mechanical specifications

Regulated Outdoor

Regulated Indoor

Conventional Indoor

SOLA *Mercury Vapor Lamp* **TRANSFORMERS**

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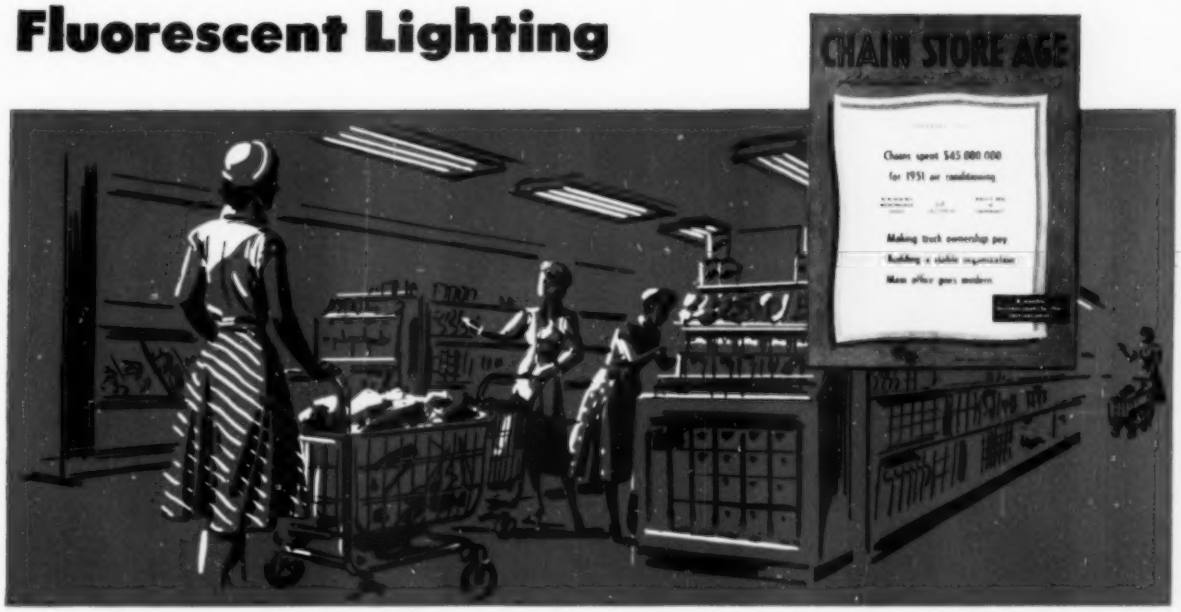
Chain Store Age Recommends CERTIFIED BALLASTS for Fluorescent Lighting



CHAIN STORE AGE, in advising chain store operators on their selection of fluorescent lighting equipment, said:

"The ballast is the heart of a fixture. The surest way to choose a ballast is to look for the Certified shield . . . it is the only assurance of long lamp life. Inferior ballasts delivering wrong wattages result in low light output."

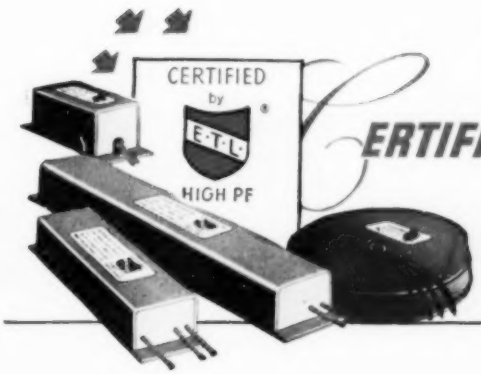
Experience has proved that CERTIFIED BALLASTS assure:

Full Lamp Life **Rated Light Output** **Maximum Ballast Life**

CERTIFIED BALLASTS are made to precise specifications, then tested by Electrical Testing Laboratories, Inc., which certifies they conform to these high standards.

Write for complete information on the types of CERTIFIED BALLASTS available from each participating manufacturer.

Participation in the CERTIFIED BALLAST program is open to any manufacturer who complies with the requirements of CERTIFIED BALLAST MANUFACTURERS.



CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

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DETROIT ARSENAL

NEW WESTINGHOUSE 1000 WATT FLUORESCENT-MERCURY LAMP —*The Cheapest Source of Mass White Light!*

Brighter, higher quality light at lowest cost—that's what engineers of the Chrysler Corporation sought for this newly erected Tank Assembly Wing of the Detroit Arsenal.

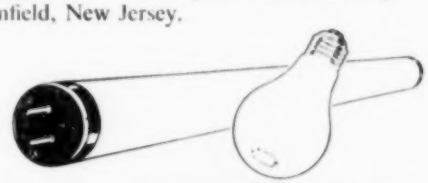
As in so many other industrial installations, the new Westinghouse 400 Watt J-H1 and the 1000 Watt C-H12 Fluorescent-Mercury Lamps met the demand for longer burning life—more economical performance due to lamps of higher efficiency—and reduced maintenance costs.

A pleasant, golden-white working light is provided by the Fluorescent-Mercury Lamp, which is both flattering to personnel and suitable for most types of lighting service. The rated lives of 4,000 to 6,000 hours respectively of the 1000 Watt C-H12 and 400 Watt J-H1 assure minimum maintenance. And the J-H1 and C-H12 may be operated from ballasts now used for the 400 Watt and 1000 Watt Mercury Lamps.

These Fluorescent-Mercury Lamps are recommended for large-scale outdoor as well as indoor applications. For 480 volt lighting circuits and for street lighting where 1000 Watt lamps are to be used, the new B-H15 is recommended.

For detailed information on how the world's least expensive source of mass white light can be employed in your present or planned lighting installations, write to Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey.

Golden-White Light Shows Real Colors. Golden-white light of Fluorescent-Mercury Lamps eliminates the need for incandescent color correction, even in color-coded assembling operations. This high-quality white light improves worker morale, aids production in industrial installations of every kind. And the long 4,000-to-6,000-hour burning life of the Fluorescent-Mercury Lamps reduces maintenance costs.



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